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Abstract

Troop readiness requires live-fire training with various types of ammunitions. By better understanding the potential environmental impacts of each type of activity, the Department of National Defence will be able to mitigate potential adverse effects by adapting the practices to minimize them. In this context, the Director Land Environment (DLE) tasked DRDC-Valcartier to initiate an R&D program on the environmental characterization of their main training areas. This report presents data acquired at the CFB Gagetown training area, following previous studies done in 2002 and 2001. The objective of the 2003 sampling effort was to further develop our understanding of the spatial distribution of explosives and heavy metals on five live-fire ranges, to assess their vertical migration and to verify the presence of TNT in background samples observed in 2002. DRDC-Valcartier performed the surface soils study in collaboration with Cold Regions Research and Engineering Laboratory (CRREL) scientists. In 2003 soil samples were collected in five specific area: The antitank range, the hand and riffle grenade ranges, one small arm range, the propellant burning pads and in the vicinity of the live firing area (background samples). In the antitank range, a new sampling pattern involving the collection of multiple increments (more than 50) in a large sampling area was evaluated to better assess the overall extent of soil contamination. Vertical profilings were also conducted to study the migration of munition related residues both in the impact area and in the firing position. Both energetic materials and metals were analyzed in all soil samples. For the samples collected in the small arms range and in the burning pads area, both total metals and leachate testing (TCLP) were conducted to obtain total concentrations and the bio-available concentrations of metals. Finally, pre- and post-blast area of two blow in place events where sampled. Results obtained for heavy metals confirmed the ones obtained in 2002 and showed a slow increase in concentration with time. In the target area of the antitank range, the main analytes of concern are: Cu, Ni, and Zn. In ponds located in the target area many parameters exceeded the industrial thresholds: Cu, As, Cr, Ni, Pb and Zn. In both grenade ranges, Cu, Ni and Zn are increasing in concentrations with time without reaching yet industrial thresholds. High levels of Pb and Sr were detected at the burn pads locations and in the small arms range, with in addition, levels higher than the industrial threshold for Cu, Zn and Sb in the small arm range. In both the small am range and burn pads samples, it was demonstrated that Pb is leachable when found in high concentrations. Measurable impacts of the blow in place events where seen with the elevation of the concentrations of various metal analytes. A decrease in concentrations of metal analytes was observed in depth profile samplings. Results obtained for energetic materials demonstrated that the large area sampling strategy was successful and a better delineation of energetic residues was performed. It was demonstrated that TNT detected in 2002 in the background samples was due to sample cross-contamination. Almost no energetic residues were detected in both hand and riffle grenades, even if they have been in used for almost two years. In the antitank range, HMX is the primary analyte of concern in the target area while NG is detected at high levels in the firing line. Profiling has shown that NG migrates to a depth of 60 cm in the soil profile. HMX, TNT and NG were detected in high concentration in the ponds located in the target area. This study was sponsored jointly by thrust 2S, Sustain, the Director Land Environment (DLE) and the Strategic Environmental R&D Program (SERDP). This final report will allow the development of an action plan to correct or mitigate identified environmental problem.

Résumé

L’entraînement des troupes à tirs réels avec plusieurs types de munitions est essentiel. En améliorant les connaissances des impacts environnementaux des divers types de tirs, le département de la défense nationale sera capable de minimiser ou corriger les impacts causés si il y a lieu. Dans ce contexte, le directeur terrestre environnement (DLE) a mandaté RDDC Valcartier afin de mettre en place un programme de caractérisation des secteurs d’entraînement majeurs des forces terrestres canadiennes. Ce rapport présente les données obtenues dans le secteur d’entraînement de Gagetown et fait suite à deux études sur les sols de surface et les eaux souterraines effectuées en 2002 et 2003. L’objectif de l’étude était de mieux délimiter la présence d’explosifs et de métaux lourds dans cinq secteurs ciblés et d’améliorer nos connaissances sur la distribution spatiales des contaminants, évaluer leur potentiel de migration verticale et vérifier la présence de TNT dans des échantillons situés à l’extérieur du secteur. RDDC Valcartier participé à l’étude en collaboration avec des scientifiques du laboratoire américain, “Cold Regions Research and Engineering Laboratory” (CRREL). En 2003, le site a été revisité et des sols de surface on été prélevés dans les sites suivant: Le site anti-char Wellington, les deux sites de tir de grenades, un secteur de tir de petit calibre, les aires de brûlage de poudres à canon, et enfin, dans le pourtour du secteur. Dans le secteur anti-char, de nouvelles méthodes de collecte d’échantillons ont été mises à l’épreuve et des profils verticaux ont été effectués afin de connaître la migration des contaminants. Ce rapport présente les résultats obtenus lors de la caractérisation des sols de surface de ces différents secteurs. Les matériaux énergétiques ainsi que les métaux ont été analysés pour chaque échantillon. Pour les échantillons prélevés dans le site de tir petit calibre et dans les aires de brûlage de poudres, les métaux totaux ont été analysés ainsi que les lixiviats afin d’obtenir de l’information sur les concentrations totales de métaux lourds mais aussi leur bio-disponibilité. Dans l’aire d’impact du site anti-char, les analytes dépassant les critères industriels sont le Cu, le Ni, et le Zn. Les sédiments des mares de boues sont fortement contaminés par le Cu, l’As, le Cr, le Ni, le Pb et le Zn. Dans les deux sites de grenade, le cu le Ni et le Zn démontrent une progression de leur concentration avec le temps. Des niveaux élevés de Pb et de Sr ont été détectés sure les sites de brûlage de poudres. Dans le site petit calibre, les analytes suivants sont détectés au-delà du critère industriel: Pb, Cu, Zn et Sb. Il a été démontré que le Pb est lixiviable lorsque présent en fortes concentrations. Des impacts mesurables des deux évènements de détonation de munitions ont été mesurés avec l’augmentation de la concentration de plusieurs métaux. Une diminution des concentrations des métaux avec la profondeur est observée dans les échantillonnages verticaux. En ce qui concerne les matériaux énergétiques, cette étude a démontré l’efficacité de nos méthodes d’échantillonnage et a permis de mieux délimiter la présence de résidus énergétiques dans le secteur antitank. Il a été démontré que la présence de TNT dans les échantillons background en 2002 était due à une contamination entre les échantillons. Très peu de composes énergétiques sont détectés dans les deux sites de grenade, et ce même près de 2 ans d’utilisation. Dans le site antichar, le HMX est le composé le plus problématique dans l’aire d’impact alors que la NG est détectée à de fortes concentrations dans la zone de tir. Le profilage vertical a démontré que la NG a migré au moins jusqu’à 60 cm de profond. Du HMX, du TNT et de la NG ont été détectés à de fortes concentrations dans la mare localisée dans l’aire d’impact. Cette étude a été supporté par le vecteur 2s, DLE et le programme américain Strategic Environmental R&D Program (SERDP). Ce rapport en conjonction avec les rapports passés rédigés sur le secteur d’entraînement permettra l’établissement d’un plan d’action ciblé pour minimiser ou restaurer les problèmes environnementaux identifiés.

Executive Summary

Military live fire training involving various types of weapons is essential to maintain the readiness of our troops, either for combat scenarios or for peace keeping missions. It is within this context that Defence Research & Development Canada- Valcartier (DRDC Valcartier) and USA Cold regions Research and Engineering Laboratory (CRREL) initiated research programs to support the sustainable training of armed forces. A specific program was dedicated to the study of the various potential environmental impacts of munitions, which positioned our departments in a state of readiness and allowed the development of a unique expertise. The first training area selected was CFB Shilo and it was characterized between 1999 and 2001. CFB Gagetown training area was selected as the second site to be investigated, based on its complementary geology and geographical locations compared to Shilo and based on its intensive use by the Canadian Forces and allied troops. The first phase of Gagetown training area was conducted in 2001 and focused on ground water and surface water. A first report was published on phase one and included hydrogeological and geological characterization and ground water and surface water quality analysis. The phase two campaign was accomplished in 2002 and two reports were produced, one on the follow up of the hydrogeological work and another one on the surface sampling of soils and biomass in major and representative live firing ranges. The site was visited again in 2003 in order to better delineate the contaminants in five specific areas and to allow the development of a complete action plan for CFB Gagetown training area. In the target area of the antitank range, the main analytes of concern are: Cu, Ni, and Zn. In ponds located in the target area many parameters exceeded the industrial thresholds: Cu, As, Cr, Ni, Pb and Zn. In both grenade ranges, Cu, Ni and Zn are increasing in concentrations with time without reaching yet industrial thresholds. High levels of Pb and Sr were detected at the burn pads locations and in the small arms range, with in addition, levels higher than the industrial threshold for Cu, Zn and Sb in the small arm range. In both the small am range and burn pads samples, it was demonstrated that Pb is leachable when found in high concentrations. Measurable impacts of the blow in place events where seen with the elevation of the concentrations of various metal analytes. A decrease in concentrations of metal analytes was observed in depth profile samplings. Results obtained for energetic materials demonstrated that the large area sampling strategy was successful and a better delineation of energetic residues was performed. It was demonstrated that TNT detected in 2002 in the background samples was due to sample cross-contamination. Almost no energetic residues were detected in both hand and riffle grenades, even if they have been in used for almost two years. In the antitank range, HMX is the primary analyte of concern in the target area while NG is detected at high levels in the firing line. Profiling has shown that NG migrates to a depth of 60 cm in the soil profile. HMX, TNT and NG were detected in high concentration in the ponds located in the target area. The work accomplished within this project was sponsored by Director Land Environment (DLE) and by a major US funding program, Strategic Environmental R&D Program (SERDP). The campaign involved many scientists from both DRDC Valcartier and CRREL, whom are co-author of the present report.

Thiboutot, S., Ampleman, Marois, A. Gagnon, A., Bouchard, M., Hewitt, A., Jenkins, T., Walsh, M., Ramsey, C., Bjella, K., Ranney, T., Environmental Conditions of Surface Soils, CFB Gagetown Training Area: Delineation of the Presence of Munitions Related Residues (Phase III, Final Report). DRDC-TR-2004-205 Defence Research and Development Canada Valcartier.

Sommaire

L’entraînement militaire avec tir réel est nécessaire afin d’assurer que les forces armées Canadiennes sont prêtes à entrer en action, que ce soit dans un contexte de conflit ou de mission de paix. La majorité de l’arsenal canadien est ainsi utilisé dans des exercices de tir dans nos secteurs d’entraînement. C’est dans ce contexte que Recherche et Développement Canada-Valcartier (RDDC Valcartier) et le laboratoire américain Cold Regions Research and Engineering Laboratory (CRREL) ont initié des programmes de recherche dédiés au support à l’entraînement durable des forces armées. Les programmes canadiens et américains sur l’étude de caractérisation des secteurs d’entraînement nous permettent de comprendre les impacts environnementaux de l’entraînement militaire et de prendre des actions correctives si nécessaire. Le premier secteur d’entraînement qui a été caractérisé entre 1999 et 2001 est celui de la base de Shilo au Manitoba. Le secteur d’entraînement de la base de Gagetown a été sélectionné en second lieu, basé sur la complémentarité de sa géologie et de sa location géographique mais aussi basé sur son utilisation intensive par les troupes canadiennes et alliées. La première phase a été effectuée en 2001 à Gagetown et a focalisé sur la qualité des eaux de surface et souterraine. Un premier rapport a été rédigé incluant la caractérisation hydrogéologique et géologique de la portion Nord du secteur d’entraînement. La seconde phase a été accomplie en 2002 et a conduit à la rédaction de deux rapports, sur la poursuite de l’étude hydrogéologique et sur la caractérisation des sols de surface et de la biomasse. Le site a été visité à nouveau en 2003 afin de mieux délimiter les contaminants dans cinq aires d’entraînement spécifiques et de mettre en place un plan d’action global pour le secteur d’entraînement. Dans l’aire d’impact du site anti-char, les analytes dépassant les critères industriels sont le Cu, le Ni, et le Zn. Les sédiments des mares de boues sont fortement contaminés par le Cu, l’As, le Cr, le Ni, le Pb et le Zn. Dans les deux sites de grenade, le Cu le Ni et le Zn démontrent une progression de leur concentration avec le temps. Des niveaux élevés de Pb et de Sr ont été détectés sure les sites de brûlage de poudres. Dans le site petit calibre, les analytes suivants sont détectés au-delà du critère industriel: Pb, Cu, Zn et Sb. Il a été démontré que le Pb est lixiviable lorsque présent en fortes concentrations. Des impacts de deux évènements de détonation de munitions ont été mesurés avec l’augmentation de la concentration de plusieurs métaux. Une diminution des concentrations des métaux avec la profondeur est observée dans les profilages verticaux. En ce qui concerne les matériaux énergétiques, cette étude a démontré l’efficacité de nos méthodes d’échantillonnage et a permis de mieux délimiter la présence de résidus énergétiques dans le secteur antichar. Il a été démontré que la présence de TNT dans les échantillons background en 2002 était due à une contamination entre les échantillons. Peu de composés énergétiques sont détectés dans les deux sites de grenade, et ce même après 2 ans d’utilisation. Dans le site antichar, le HMX est le composé problématique dans l’aire d’impact alors que la NG est détectée à de fortes concentrations dans la zone de tir. Le profilage vertical a démontré que la NG a migré au moins jusqu’à 60 cm de profond. Du HMX, du TNT et de la NG ont été détectés à de fortes concentrations dans la mare localisée dans l’aire d’impact. Ce travail a été financé par le directeur des forces terrestres et par un programme de financement de la recherche américain appelé Strategic Environmental R&D Program (SERDP). La campagne a impliqué de nombreux scientifiques de RDDC Valcartier et de CRREL, qui sont co-auteur du présent rapport.

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Acknowledgements

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1. Introduction

Troop readiness requires intensive training in Canada. Moreover, many other countries use our training ranges under international agreements. Testing and training ranges are key elements in maintaining the capability, readiness and interoperability of the Armed Forces. The potential for environmental impacts of live fire training, includes the accumulation of munitions related contaminants in the surface soils and biota and the potential contamination of the underlying ground water, which mandates that our departments demonstrate responsible management of these facilities in order to continue testing and training. Additional research will increase the knowledge base supporting the credibility of guidance and recommendations for range sustainability. The most extensive study achieved up to now was conducted at CFAD Dundurn where the impact of the open detonation of Canadian obsolete munitions was extensively studied [1]. The first actual training range visited was the CFB Shilo training area where detailed research was achieved to assess the environmental impacts of many types of live fire training [2-3]. Anti-tank firing ranges across Canada were also the topic of other studies [4-6]. Moreover, many papers were written in recent years concerning the fate and analysis of explosives in various types of sites [7-32].

Military training exercises have been conducted on CFB Gagetown since 1954. Currently, this base serves as one of the major training facilities for the Canadian Forces and is also used by troops from the Untied States of America, United Kingdom, and Australia. It is the main training area for eastern Canada where most of the long-range, high calibre live firing is conducted. The base is located 20-km southeast of Fredericton, New Brunswick, and covers an area of about 1100 square km (Figure 1). Approximately half of this territory serves as Static Range Impact Areas (SRIA) for infantry, artillery, air defence, engineer, and armoured vehicle live-fire training, while the southern portion of the area is used as a general manoeuvre area. Recently, awareness has increased that the energetic residues and heavy metals associated with munitions can be released to the environment during training activities and over time potentially contaminate the underlying ground water. For instance, munitions training and testing exercises were suspended at the Massachusetts Military Reservation (MMR) following the discovery of low concentrations of RDX in the ground water beneath the main training area (EPA Order #2). On military training ranges, munitions related pollutants can be released to the environment from breaches in the casings of unexploded ordnances (UXO) or partially exploded ordnance, from poor disposal practices, such as unconfined burn operations, from blow-in-place operations, and from live-fire operations.

Troop readiness and effectiveness depends upon the availability and use of facilities for training, and for development and testing of munitions systems. Assuring the continued availability of ranges for these activities hinges on the development and implementation of sound management practices. Before a management strategy can be proposed, potential problems must be identified, ranked, and corrective measures developed to prevent or limit pollutants from migrating to ground water. The Strategic Environmental Research and Development Program (SERDP) has funded several

studies directed at the assessment of source strengths and pathways of munitions residues on military training facilities. Moreover, Director Land Environment (DLE) tasked DRDC-Valcartier to initiate an R&D program involving the environmental characterization of their main training areas learn the impacts of various types of live firing training activities. The work carried out at CFB Gagetown was therefore co-sponsored by both programs. These programs have supported several joint efforts of personnel from the Defence Research and Development Canada (DRDC) and the U.S. Army Engineer Research and Develop Center (ERDC).

This report presents the results of the third characterization (Phase III) carried out at CFB Gagetown training area in October 2003. The first phase was conducted in the fall of 2001 and was dedicated to the drilling of wells on the northern half of the base to collect ground water samples and to perform the hydrogeological characterization of the site [20]. Phase II consisted in a joint effort both surface and sub-surface where more wells were drilled and sampled in the southern half of the base and surface soils and biomass were collected by a joint Canadian and US team [21]. The information gained was of strategic value for CFB Gagetown and represented a detailed study on the characterization of such a huge and intensively used training area. Results of phase II indicated a need to re-sample the five following area: background, antitank range, grenade ranges, propellant burn pads and small arms ranges. The objective of the sampling effort in 2003 was to define our understanding of the spatial distribution and fate of metals and energetic residues. Two scientists from the Biotechnology Research Institute, Montréal, Québec, took the opportunity to visit the Wellington antitank range to collect large amounts of soil to perform an ecotoxicological study on the impact of mixed contamination by both heavy metals and explosives. Fieldwork was conducted in the fall of 2003 and data treatment was done in the winter and spring 2004. This work was carried out under the new Sustain Thrust 2s within the working breakdown element 12 se 07 of DRDC-Valcartier program and was also supported by DLE and the US funding program SERDP.

2. Experimental

2.1 Field Investigation

Fieldwork was conducted between October 20 th and October 25 th 2003 at CFB Gagetown, both in the training area of and around base limits for background sample collection. The surface sampling was concentrated in the live fire impact areas located in the northern portion of the base (Figure 2). Sampling strategies were designed on site, depending of the landscape, visual observation of the area, the information gathered from the Explosive Ordnance Disposal (EOD) unit personnel and also based on the expertise gained in the previous Gagetown study [21]. The surface soil sampling was conducted by all co-authors of the present report, following new strategies dedicated to enhance our knowledge of the dispersion and fate of munitions related contaminants. Most of the characterization effort was conducted in the Wellington Antitank range, both in the firing positions and in the impact area.

2.2 Chemical Parameters and Analytical Methods

All samples were analysed for metals and energetic materials (RDX, HMX, TNT, 2,4-DNT, Tetryl and their main degradation by-products). Metals were analysed by Inductively Coupled Plasma Mass Spectrometry (ICP/MS) by RPC Laboratory under a sub-contract. All parameters available by this method were included. For some specific samples, soil leachate tests were done (TCLP procedure) to verify the leachability of the metals. Energetic Materials were analysed by Cold Regions Research and Engineering Laboratory (CRREL) using High pressure liquid chromatography (HPLC) and Gad Chromatography (GC-ECD) following EPA methods 8330 and 8095. [21].

2.3 Safety of the Sampling Teams

Two sampling teams were involved in the Phase III campaign. Canadian EOD experts were present at all times whenever a sampling team was working in a Unexploded ordnance (UXO) contaminated range.

A schedule was established prior to the campaign in collaboration with Dr. Thiboutot from DRDC Valcartier, Ms Ann Jones from Defence Construction Canada (DCC) and the range Control Command Post. The schedule was based on the needs of the sampling team and estimated time needed to perform surface characterization on each range. Any modification to the accepted schedule had to be approved by Range Control. The schedule insured that a safety template was applied at all times with no live firing conducted near teams while they were in the live-fire area.

A detailed safety briefing was given to all teams on October 20th. by Sgt Paul. He stated that the range control and EOD staff would be dedicated to the success of our

sampling campaign and that they would give full support to our study. The safety briefing included detailed information on the type of munitions that the teams might encounter on ranges and how to minimise the danger associated by working in such an environment. Clear instructions were given on the liaison with range control either by cell phone or radio provided by range control. Each team had to always request permission to enter the danger red zones at the gate and to inform range control when exiting of the danger zone.

Two EOD specialists were dedicated to the sampling teams and were always present with the team when entering a red danger zone. They actually drove and walked all day with scientists to insure their safety when in a danger zone. They also provided useful and detailed information whenever appropriate. EOD also offered to the scientific team the possibility of sampling two blow-in-place (BIP) events, one in the Wellington Antitank Range and one in the Hersey Impact Area. The first one involved the open detonation of two 84-mm rounds and the second, the detonation of a 500 pounds bomb. This represented very interesting trials, and both events were included in this study.

2.4 Sample Handling and Treatment

Most of the samples collected in this study were of the top 2 cm of the surface and were comprised mostly of soil; however, in a couple locations vegetation (mosses and grasses) was included as part of the sample. In addition, sediment, surface water, and three soil profile samples at multiple discrete intervals were collected. Composite samples were stored in polyethylene bags, while the sediment, soil profile, and water samples were stored in amber glass bottles with Teflon lined caps. The water samples were stored in 500-mL narrow neck amber bottles and the discrete soil and sediment samples were stored in wide mouth 120-mL bottles. Immediately after collection, all samples were placed in coolers. The soil, sediment and water samples were refrigerated with ice and sent to the Engineering Research and Development Center-Cold Regions Research and Engineering Laboratory (ERDC-CRREL) for processing and analysis. For metals analysis, samples were either sent directly to RPC laboratory by Ms Jones from DCC, or sent back from CRREL to RPC after homogenisation of the main bulk samples. In the case of the background and burning pads sample, two sets of samples were collected: one for CRREL for explosive residue analysis and one for RPC laboratory for metal analysis. In the case of the Vimy small arms ranges, samples were analyzed only for metals. Results for metals analysis were sent to Dr Thiboutot by RPC laboratory. Detailed sample log can be found in Appendix 1 on the attached CD.

At CRREL all of the soil and sediment samples were air-dried, then passed through a 2-mm sieve. Both fractions were retained and weighed; however, only the smaller particle size fraction was processed for analysis. Following sieving, sub samples were removed from all of the samples for the metal analysis with the exception of the background and burn pad samples. Both the background and burn pad samples were equally divided in the field and sample splits were shipped to both CRREL and a contract laboratory. At CRREL sub samples for metal analyses were spread out on flat

surface, and small increments from 20 or more different locations were composited. These composites weighed either 5 or 105 g depending on the weight of the < 2 mm portion of the sample. For those samples weighing less than 1500 g the smaller subsample weight was removed. Contrarily, for those samples weighing more than 1500 g, the larger subsample weight was removed.

For energetic analyses, acetonitrile was added directly to the discrete soil and sediment samples (120 ml glass bottles). The volume of solvent was twice the weight of the air-dried (< 2 mm) soil. In some cases the sample was transferred to a 240-mL wide mouth bottle to accommodate the two-fold volume of solvent. After the addition of acetonitrile the sample jars were shaken on a platform shaker at 200 rpm for 18 hours. All of the composite samples were ground in a ring mill (Labtech EssaLM2) for 60 sec., then a 10-g subsample was removed by randomly obtaining 30 or more small increments and transferring into a 40-ml glass vial with a Teflon lined septum cap. To assess the sample processing protocol (grinding and subsampling), triplicate subsamples were removed for extraction and analysis for one out of every ten composite samples. After the addition of 20 mL of acetonitrile to each vial, the subsamples were extracted in a temperature controlled sonic bath for 18 hrs. Following extraction by either shaker table or sonic bath, an aliquot of the solvent extract was filtered through a 0.45-µm, 25-mm Millex FH filter.

The water samples were first pre-concentrated through a solid-phase extraction (SPE) cartridge [18]. This technique retains the energetic residues on a Porapak RDX cartridge (Sep-Pak, 6-cm3, 500-mg, Water Corporation) which was subsequently eluted with 5.00 mL of acetonitrile.

2.5 Sample Analysis

For energetic materials, samples (SPE, shaker table, and sonic bath), were analyzed by either gas chromatography with electron capture detection (GC-ECD) or reversed-phase high performance liquid chromatography (RH-HPLC), or both. The GC was a HP6890 equipped with a micro cell Ni63 ECD and the analysis protocol followed the EPA SW-846 Method 8095 guidelines [15-16]. Primary and secondary GC-ECD analyses were performed using a 7-m x 0.53-mm ID fused silica column, with a 0.5-µm coating of 5%-(phenyl)-methylsiloxane (RTX-5MS from Restek, Bellefonte, PA) and a 6 m x 0.53 mm ID fused silica column with a 1.0-µm coating of a proprietary phase (RTX-TNT-2 also from Restek), respectively. RP-HPLC analyses were performed on a modular system (Thermo Separation Products Inc., San Jose, CA) consisting of a P1000 isocratic pump, UV2000 dual wavelength absorbance detector set at 210 and 254 nm and AS3000 auto sampler. Analyte separations were performed using the 15-cm x 3.9-mm (4-mm) NovaPack C-8 column (Waters Chromatography Division, Milford, MA) eluted with 15:85 isopropanol/water (v/v), at 1.4 mL/min. Both standards and solvent extracts were diluted 1:3, acetonitrile to water, for HPLC analysis and were run undiluted for GC-EDC analysis. Samples with energetic residue concentrations of greater than 200 µg/L were analyzed by RP-HPLC. Estimates of the detection limits for soils by both methods of analysis are listed in Appendix 2. Reporting limit estimates were based on method detection limits [15-16].

Metals were analyzed by RPC Laboratory by ICP/MS and total metal concentrations were obtained by using EPA Method 3050 [33] involving a nitric acid/hydrogen peroxide digestion. Leachate testing used EPA Method 1311, which entails buffered acetic acid leaching at a 20:1 liquid to solid ratio [34].

2.6 Sample Labelling System

The samples were labelled as follow:

BG: Background samples collected outside of training area (with GPS location);

BP: Burning Pad (with GPS location);

S-V: Vimy small arms range;

GAG 001-170: Labelling system used by CRREL. Detailed descriptions of each sample collected and analyzed by CRREL can be found in tables 1 to 10 (see attached CD).

3. Range Description and Sampling Strategy

The surface sampling team collected a total of 189 soil samples in the following areas: background samples outside the live-fire training area (14 samples), New Castle Rifle and Hand grenade ranges (7 and 18 samples respectively), Wellington anti-tank range (115 samples), Vimy small arms range (11 samples), burning of propellants pads/locations (10 samples), and a set of samples before and after a 500-pound bomb was blown in place (14 samples). The rational for re-sampling these areas will be presented in the following sections. In general, the main goal was to delineate more precisely the presence of munitions related contaminants in the antitank and small arms ranges, to validate the presence or absence of TNT in background samples, and to evaluate the evolution with time of the contaminant concentrations in the grenade ranges. Results obtained for energetic material analyses and metals are presented in tables 1 to 11 while pertinent information on each sample can be retrieved in Appendix 1 (see CD inserted at the end of the report). Seven water samples were also collected in ponds and craters in the antitank range.

Many sampling patterns were used in the present study, based on our combined previous experiences, visual inspection, the presence or absence of targets, and the general settings of the ranges. Mostly surface soils (from 0 to 2 cm deep) were collected; however, some core samples were collected in specific area of interest. The cores were collected with a manual corer designed by the CRREL team. It allowed easy sampling 0 to 10 cm deep, with the possibility of discriminating at least 3 layers of sub-samples (Figure 3). The surface sampling design used most frequently for this investigation involved the collection of multiple increments within a designate area, while systematically moving from one end to the other. Along with this sampling protocol, sample were collected along linear transects to replicate the protocol used in 2002. Pits were also dug to allow subsurface sampling in the antitank range, both in the impact area and the firing position (FP).

3.1 Background Samples (BG)

In the 2002 study, sixteen background samples were collected to obtain a representative non-anthropogenic mean of the concentration of metals in the Gagetown geologic formation. In other words, these samples were obtained to generate mean background values for analytes of concern to be compared with values obtained from samples inside the live training area. In the field, all of the background samples were equally split prior to shipment. Energetic materials were analyzed last year to verify that no explosive would be detected outside of the live firing range border. However, traces of TNT were detected in most of the background samples. It was then imperative to re-sample the same locations in 2003 to verify if TNT cross-contamination was generated either in transport or laboratory treatments. Moreover, the collection of another set of background samples would allow a better and more representative estimation of the mean results for metal analytes in the Gagetown geological formation for sake of comparison with results obtained in the live fire

ranges. In 2003, 14 samples were collected including 2 field duplicates. During this investigation all of these samples were kept in a separate cooler and never exposed to the other samples in order to avoid any risk of cross-contamination. The sampling locations were chosen as near as possible to the sampling location from last year study. GPS locations of the samples were recorded and are integrated into the sample nomenclature for any further references. The labelling was S-BG-GPS position.

3.2 Wellington Anti Tank Range

A total of 115 soil samples were collected in the Wellington antitank (WAT) range. The WAT was covered with shrapnel and propellant residues (Figure 4). The range is located north of the Argus and Greenfield Impact area and is approximately 5 km^2. It is located in the northern part of the training area at the intersection of the Shirley and the Schanes roads. Six tanks on the range at various distances from the firing position (T1 to T6) serve as targets for training with 66-mm M72 LAW M72E5 rockets and 84-mm AT HEAT rounds. Targets one to five were respectively, the nearest and the farthest from the firing position, while target six is located on the other side of a small road within the range (Figure 5).

The GPS positions of the five sampled targets (T) and central firing position (FP) were as follows, respectively:

T1: 00998 77317

T2: 01003 77311

T3: 01042 77271

T4: 01062 77245

T5: 01084 77206

FP: 00849 77364

Soil, sediment, and water samples were collected in the Wellington anti-tank impact range. Samples were collected in the target zone (impact zone), in front and behind the firing position, and within an ordnance disposal bunker before and immediately following the blow-in-place of two UXOs.

In the impact zone the majority of sampling was performed around tanks 1 through 4 (Figure 5). These four targets were positioned closest to the firing point and each was on the edge of a gravel assess road. Based on debris (metal fragments and chunks of rocket propellant) present on the surface of the ground and the number of penetration holes in the armor these four targets experience the greatest amount of activity. In addition, all four of these targets had areas in front and behind them had been strafed (defoliated). The lowest depressions in these strafed areas were filled with water, creating small pools. Dense vegetation, comprised of grasses and bushes, grew adjacent to both the access road and strafed areas.

In the heavily impacted area around targets 1 through 4 (Figure 4) eight composite (>40 increments) surface soil samples (G1-G8) were collected by systematically walking around the entire defoliated area and collecting increments at approximately 5 meter intervals. The area sampled was approximately 110 m in length and ranged in width between 20 to 40 m. Four different samplers performed this task twice. Using this sampling strategy, each location within the designated area was only sampled once. These composite samples included surface soils from the access road and from within the areas strafed on either side of the road that were not covered with water. Composite samples were also collected from the following sub-strata; the strafed areas behind the four tanks (G15-G17), road surface (G18, G19), and within a crater on the edge of the road between tanks 3 and 4 that may have been formed by a blow-in-place operation (G171). In addition, three additional strata were sampled that were outside of the initially designated stratum. These strata consisted of two vegetated areas, one next to tank 1 (G9, G10) and the other between tanks 2 and 3 (G11, G12, G20), and a strafed area in front of tank 6 (G13, G14) (Figure 5). In each case the sampling strategy was similar to that described previously; however, the number of increments varied depending on the size of the area being sampled. Each increment collected to build these composite samples was obtained with a stainless steel scoop (5-cm diameter) by removing the top 2-cm of soil. These surface samples were comprised mostly of soil with the exception of those collected from the two vegetated areas, which also contained grass and moss.

In addition to the collection of surface samples, a pit was dug for profile sampling (discrete interval sampling), eight sediment and 6 water samples were also collected. A rectangular pit, 31-cm deep, was dug in front of tank 2 for the collection of a profile sample (Figures 6,7). The bottom of the pit was sampled with a small coring tool (2.7 cm i.d.) by taking three 7 cm deep cores (G136). Then thirteen discrete interval samples were collected with a stainless steel scoop from the side of the pit closest to the tank starting from the bottom of the pit and removing a portion of the side wall while progressing toward the surface (G128-G135). The depth interval of the discrete samples that were removed from the sidewall ranged from 1.5 to 5 cm. Sediment samples were collected from two separate pools of water that were in front of tanks 1 through 3. Sediments were obtained by attaching a stainless steel scoop to a metal pole. The first six sediment samples (G137-G142) were collected within 2 to 3 meters of the tanks (north and south side of the pools). The last two sediment samples (G143, G144) were collected several meters in front of tank 3. Water samples were collected by dipping a 500-ml glass bottle beneath the surface of the two pools in front of tanks 1 through 3 and from a water filled crater in front of tank 4. Water samples were collected at a distance of 4 and 10 m on the north side (G171, G172) and at 3 m on the south side (G173) of the pool in front of tanks 1 and 2. Likewise water was collected 12 m on the north side (G174) and at 2 m on the south (G175) of the pool in front of tank 3. A single water sample was collected from a crater located some 15 m in front of tank 4 (G176).

The first sampling activity performed at the firing point on this range was associated with the blow-in-place of two 84-mm HEAT rounds (approximately, 80 g Octol; 70% HMX and 30% TNT). This operation was performed within the explosive ordnance disposal (EOD) pit that was horseshoe shaped. This bunker was made by surrounding

a flat area (3-m^2) on three sides with a 2-m high mound of soil. Surface samples were collected immediately before and after the detonation of two 84-mm rounds. Each 84-mm weapons were open detonated with the use of one block of C4 per round. These munitions appeared to contain both a warhead and rocket propellant pack within a single casing (Figure 8). The rounds were placed on the ground about 2 meters from each other and a 1 LB (450 g) block of C4 (91 % RDX) was placed next to each (Figure 9). The blocks of C4 had a timed fuze to initiate detonation a couple of seconds from each other. Duplicate composite soil samples (G21, G22; 14 increments) where collected of the bottom (ground) surface of the bunker and from within a 1 m diameter circle (G23, G24; 30 increments) located between the two rounds. The same sampling protocol (ground surface G25, G26; circular area G27, G28) was repeated immediately after the blow-in-place operation. In addition composite samples (G29, G30) were collected within the detonation craters (blackened soil with a slight depression) that were formed (Figure 10). Each increment collected to build these composite samples was obtained with a stainless steel scoop by removing the top 2 cm of the surface.

Behind the 40-m long firing line on this range, composite samples of the top 2-cm were collected as far back as 50 m using a stainless steel scoop. Most of the area behind the firing line was covered with soil and gravel; however, the surface was covered with grass in the northwest corner. Prior to sampling flags were positioned at distances of 1, 2, 5, 10, 20, 30, 40, and 50 m, on both ends of the firing line (Figure 5). Most of the designated sampling areas were 40 m long and ranged in width from 1 to 30 m (running parallel to the firing line). Exceptions to these rectangular sampling zones was the collection of samples from two sub-strata within the 20- and 50-m zone and the collection of three samples from 1 m^2 areas immediately behind three of the fixed firing positions.

Along the firing line were 5 fixed firing positions. Three consisted of a small concrete pad from which rockets could be fired from both standing and kneeling positions (Figure 11). In between the three concrete firing structures were two foxholes. Immediate behind the three concrete positions 10-increment composite samples where collected in 1-m^2 areas (G31-G33). Behind the firing line, single or duplicate 30 increment composite samples were collected in the following 40-m long zones that ranged in distances of:

• 1 to 2 m (G34, G35)

• 2 to 5 m (G36)

• 5 to 10 m (G37)

• 10 to 20 m (G38)

• 20 to 30 m (G39, G40)

• 30 to 40 m (G41)

• 40 to 50 m (G42)

• 0 to 20 m (G43, G44)

• 20 to 50 m (G45, G46), from the firing line.

In addition, in the 20- and 50-m zone, two composite samples were collected in the road (non-vegetated) portion (G51) and in the vegetated area (G52). The increments collected to build these composite samples were obtained with a stainless steel scoop by removing the top 2 cm of the surface. Within the designated rectangular sampling zones increments to build the composite samples were obtained at randomly chosen points as the sampler systematically moved from one end to the other.

Composite samples were also collected in the buffer zones, to the north and south of the 40 x 50 m marked area behind the firing line. In the buffer zone on the north side a single composite sample was obtained with a stainless steel coring tool (i.e., bulb planter with 4.8 cm i.d.). The core was split at the root zone separating the vegetated topsoil (0 to 2.5 cm, G49) from the subsurface portion (2.5 to 5 cm, G50). In the south buffer zone replicate composite soil samples where collected (G47, G48) with a stainless steel scoop.

At the middle of the firing line and 10 m in the rear a 63-cm deep rectangular pit was dug for the collection of a profile sample (Figure 12). Twelve discrete interval samples were collected with a stainless steel scoop from the side of the pit furthest from the firing line. The intervals were collected starting at the bottom and moving to the surface (G159-G170). The depth interval of these discrete samples ranged from 3 to 10 cm.

In front of the firing line the ground surface was covered with vegetation consisting of grass, moss, and small bushes. Composite samples of soil were collected in rectangular zones as well as along linear transects using the same general sampling strategy as used behind the firing line. However, because of the vegetation sample increments, the top 2-cm were removed with the stainless steel coring device (i.e., bulb planter with 4.8 cm i.d.) and the underlying soils were collected. The rectangular zones and transects were parallel to the 40 m long firing line. In front, flags were positioned at 10, 20, 30, 40, 50, and 60 meters down range. Single or duplicate composite samples comprised of 30 increments were obtained in the following zones that ranged in distances of:

• 0 to 10 m (G53)

• 10 to 20 m (G54, G55)

• 20 to 30 m (G56)

• 30 to 40 m (G57, G58)

• 40 to 50 m (G59)

• 50 to 60 m (G60, G61), from the firing line.

Thirty increment composite samples were also collected along linear transects. Duplicate linear composite samples were collected at 10 m (G62, G63) and single composite sample were collected at 20-(G64) and 50 m (G65).

In the middle of the firing line and 10 m in front, a 57-cm deep rectangular pit was dug for the collection of a profile sample (Figure 13). Fourteen discrete interval samples were collected with a stainless steel scoop from the side of the pit farther from the firing line and moving to the surface (G145-G158). The depth interval of the discrete samples that were removed from the side ranged from 2 to 5 cm.

3.3 New Castle Hand Grenade Range

This is a relatively new hand grenade range that has been in use for two years. Range control personnel were able to provide us with the exact number of hand grenades fired since the range opening by consulting their log book. It revealed that 2459 hand grenades were detonated on this range, or approximately 1200 grenade fired per year. The impact area in front of the cement throwing bunkers was 55 m wide and was covered with medium grit sand and pebbles. Surface composite samples (0-2 cm) where collected with a stainless steel scoop along linear transects and in designated area that were parallel to the throwing bunker, using similar sampling strategy as used at the firing point. Initially, markers were positioned at 5, 10, 15, 20, 30, 40, 50, and 60 m from the bunker (Figure 14). Single and duplicate 25-increment composite samples were collected along the following linear transects:

• 10 m (G78)

• 20 m (G79, G80)

• 30 m (G81)

• 40 m (G82, G83)

• 50 m (G84)

Single and duplicate 30-increment composite samples were collected to the right and left side (split down the middle of the impact range) of zones between the following down range distances:

• 0 to 5 m, left (G85); right (G90, G91)

• 5 to 10 m, left (G86, G87); right (G92)

• 10 to 15 m, left (G88); right (G93)

• 15 to 20 m, left (G89); right (G94)

Finally, a 30-increment composite sample was collected within the zone 50 to 60 m from the bunker (G95). These 11 samples were collected to assess whether munitions related residues were still to be found on each side of the range and at a farther distance behind the range. This was decided following last year results which showed uniform concentrations all across the sampled area.

3.4 40 mm New Castle Rifle Grenade Range

This training range for 40-mm rifle grenades also has only been operational for a little more than one year. Range control was able to provide us with the number of rifle grenades fired on the range since its opening: 1206 grenades, or approximately 600 grenades were fired per year. In a zone 100 to 130 m down range from the firing line, three 30-increment composite samples were collected, one for each third of the range going left to right (Figure 15, G96-G98). This same sampling pattern was repeated in a zone 170 to 200 m down range behind a second pair of targets (G99-G101). One duplicate composite sample (G102) was collected on this impact range, behind the left 160-m target. All of the samples were from the top 2 cm and were collected with a stainless steel scoop.

3.5 Blow in Place Location of 500lb-bomb

Surface samples and a single water sample were collected on Hersey impact range where an Mk82 500-lb bomb (82 kg tritonal, 80% TNT, 20% aluminum) had landed and was blown-in-place. This range is primarily used for training with high explosives and illumination artillery projectiles. The bomb was positioned with the nose end buried in the topsoil, leaving only the back half and fins above the ground surface (Figure 16). The 20-m diameter area around this UXO was heavily vegetated. On one side the surface was very wet (cattail marsh), and on the other side were several small bushes. Prior to detonation with the use of 3 blocs of C4, surface soil samples were collected around the bomb using a stainless steel coring tool. Cores were split into two sections (0 to 3 cm top, 3 to 6 cm bottom). One 10-increment composite was collected on the wet side at a distance between 5 and 20 m from the bomb (G66 0-3 cm, G67 3-6 cm), and one was collected on the other side 5 and 10 m (G68 0-3cm, G69 3-6 cm). To blow-in-place this UXO three blocks of C4 (0.45 kg) were taped to the back end and then wrapped with detonation cord. The detonation formed a crater approximately 2.5 m deep and 8 m in diameter (Figure 17). The soil from the crater covered most of the surface that had been sampled prior to detonation. Triplicate composite surface (0-2 cm) soil samples comprising more than 63 increments, were collected within the crater with a stainless steel scoop by systematically taking increments at 1 m^2 intervals (G70-G72). Likewise, triplicate, randomly located 55 increment composite samples were collected while systemically moving around the crater covering an area 0 to 10 m from the rim (G73-G75). Between 10 to 20 m from the rim, duplicate 25-increment composite samples were collected using this same strategy; however, the coring tool was used to obtain the top 2 cm (G76, G77). In addition, a surface water sample (G177) was collected in the pool that was 10 from the rim of the crater.

3.6 Burning Pads

A recent decision was made at Gagetown training area to bring excess artillery propellant to two centralized locations for burning as opposed to burning in the field wherever the artillery guns happened to be firing. This decision was made to better control the burn procedure. Therefore, burn pads of concrete approximately 20 cm thick were installed at each burn location in order to prevent the burned residues from contaminating the soil. At each burning location~~s~~, two concrete burn pads (A and B) were installed. The burn pads are rough slabs approximately 2 m x 2 m located in the middle of a large flat area cleared of vegetation. The eight burning pads and the surrounding areas were sampled to verify the localized impact of this activity in both 2002 (only two locations) and in 2003 (four locations).

At all locations, despite the presence of the concrete pad, large amounts of propellant had obviously been burned on the adjacent ground. These burn marks were clearly evident visually as scorched and blackened strips approximately 30 cm wide by 3 to 5 m long directly on the soil. The preference for burning excess propellant is to lay it out in long narrow piles of these dimensions, which the concrete pad cannot accommodate. Use of the pad greatly increases the amount of time required to dispose of the propellant as relatively small amounts can be burned at any one time on the pads. This accounts for the propellant being burned on the ground very close to the burn pad. Almost every burn mark had small amounts of unburned propellant along its outer extremity. No visible propellant grain was included in the composite samples. The following four locations will be referred to as burn pad # 1 to 4, respectively:

BP1: North of Dingee Wood area,

GPS A pad: 0713612-5077216, GPS B pad: 0716505-5069160

BP2: East of Lawfield Impact

GPS A pad: 0716525 5069213, B pad; 0716505 5069160

BP 3: South of Rockwell Wood

GPS A pad: 0710300 5063140, B pad: 0710313 5063189

BP4: West of Rockwell Impact

GPS A pad: 0702632 5068613, B pad: 0702680 5068901

The burn pads themselves were blackened and had clearly been used for their intended purpose (Figures 18-21). The concrete, being very rough and porous, could not be methodically sampled and results would be of no interest. Instead, the soil immediately beside the pads was sampled, in the water run-off channels caused by rain

or in burn marks. The samples were composites of at least 25 increments. In general, the sampling area was between 0 and 1 m outside of the concrete pad limit. Burnpads at locations 1 and 2 had obviously been more used (figure 18-20) than pads 3 and 4 (figure 21).

3.7 Vimy small arms Range

In 2002 three small arms ranges were sampled to verify their potential contamination by heavy metals. In 2003 the Vimy small arm range was re-sampled to compare with results from last year and verify the evolution of the contamination with time, to include the firing lines in the sampling study and to run leachate tests (TCLP) on the soil samples to verify the leachability and bio-availability of the metal analytes. Eleven soil samples were collected following the sampling pattern illustrated in Figure 22. These samples were labelled S-V-x-y, where x and y were the target numbers. Moreover, a composite sample based on at least 25 discrete sub-samples was collected at each of the Vimy firing lines at 100, 200 and 300 m from the target line. These were labelled S-V-FP-xm. These lines were sampled based on the fact that small arm primers are small sources of lead that might be deposited on the firing point and accumulate with time. Since military personnel often lie down to practice firing, to verify the lead concentration detected in these lines was needed. Two deeper samples were also collected in front of target 4 and 8 with the help of a hand auger. The portion between 20 and 30 cm deep was collected, homogenized, and sent for analysis. They were labelled S-V-4 or 8 depth.

4. Results and Discussion – Energetic Materials

4.1 Data Quality

With the exception of tetryl the energetic analytes used in the laboratory control samples were recovered within a ±15% expected concentration (Appendix 3- attached CD). Erratic recoveries of tetryl during spike and recovery studies have been attributed to the instability of this energetic compound (personal communication, M.E. Walsh). Triplicate subsamples were taken from 11 of the composite samples to assess the laboratory processing protocol. Among the triplicates, 38 samples had analyte concentrations above the detection limits for each of the three subsamples, and in 3 cases this failed to occur. In all three cases where detectable levels of energetic residues were absent in all of the subsample the concentrations were below 0.065 mg/kg.

The results obtained for the laboratory triplicates are shown in Appendix 3. This table contains the average, standard deviation and relative percent difference (RSD) for each of the 38 cases mentioned above and includes the overall average RSD for each of the energetic analytes detected in at least three different sets of triplicates. For HMX, RDX, 2ADNT and 4ADNT the overall average RSDs were below 6.1%, demonstrating good reproducibility among the subsample triplicates [31]. For TNT the overall average RSD was 12%, because of the inclusion of a sample that was collected in heavily vegetated area (G10, 43% RSD). If the RSD for this vegetated matrix sample is not included, the overall average RSD drops to below 4%. The RSDs for NG and 2,4-DNT for the triplicate subsamples were frequently above 10%, and for both of these analytes the overall average RSDs were above 28%. NG is an ingredient in both double and triple based propellants and once available to soil microorganisms rapidly degrades [10]. 2,4-DNT is present in single based propellants. Because these two energetic residues persist on training ranges, we believe they are retained (imbibed) by particles of nitrocellulose (NC). Both particles of NC and the presence of a large amount of vegetation in a sample matrix confound efforts (sample homogenization) to prevent distributional and compositional error from influencing the ability to obtain representative subsamples [26, 31]. Efforts are currently underway to determine if longer sample grinding times or other methods of mechanical sample processing can further improve subsampling precision for these types of sample matrices (M.E. Walsh personal communication).

4.2 Background Samples

Table 1 shows the results of the analysis of the 15 background soil samples. Two of the background samples showed energetic residues concentrations for NG of about 3.6 mg/kg. RDX and 2,4-DNT, as well as NG were also detected in some of the other background samples; however, only at trace levels (< 0.023 mg/kg). Overall, there

were six detections of NG, three for 2,4-DNT, and one for RDX. The previous investigation found TNT to be present in all of the background samples [21]. The TNT ranged in concentration from 0.011 to 2.4 mg/kg; however, the median concentration of TNT was 0.040 mg/kg, and therefore, most of the concentrations established were at trace levels. NG, 2,4-DNT, RDX, 4ADNT, 2ADNT, and HMX were also detected in background samples collected for the initial investigation. The highest concentration established for this group of analytes was 0.068 mg/kg for NG, all of the other concentrations were below 0.036 mg/kg.

The explanation provided for the presence of TNT in the background samples collected during the initial investigation was that they had become contaminated during shipping, handling, or sample-processing [21]. During the initial investigation TNT was present at concentrations of greater that 100 μg/kg in a couple of the samples. The handling of samples with high concentrations of TNT in the same general area as those from background locations requires that special precautions be taken. This potential problem and the lack of TNT in the second set of background samples collected at the same locations, support the cross contamination theory.

The highest concentrations of NG established by both investigations were for samples collected at the same background location. This sampling location was on the edge of the woods adjacent to the firing point on the Wellington antitank rocket range. During the initial investigation we established that NG was present at concentrations as high as 1,100 mg/kg (0.11%) behind and 420 mg/kg in front of the firing point [21]. This energetic residue was distributed at this location as a result of firing rockets that have either double or tripled-based propellants. In both of these propellants, NG is imbibed into nitrocellulose (NC), that upon burning produces an aerosol cloud (smoke) comprised of fine particles that can become dispersed over a large area [31]. Since the background samples were collected only about 200 m from the firing line, the probability that small particles of the propellant residues were deposited in this location is high. The trace levels of RDX, NG, 2,4-DNT and TNT that were detected both in 2002 and 2003 in background samples can be attributed to sample cross-contamination in 2002 and to laboratory (glassware) contamination in 2003, with the exception of S-BG-00800-77309 for which NG presence should be attributed to the proximity of the Antitank firing position.

4.3 Wellington Antitank Rocket Range

To characterize energetic residues in the impact zone different sampling strategies were used by each of the investigations. During this investigation the area that appeared to have received the most live-fire was treated as a single stratum. This strategy comprised the non-vegetated areas around tanks 1 through 4, including the road and the strafed areas in front of and behind the tanks (Figure 5). During the initial investigation of this range, we collected composite samples within 1 and 2 m around each of the five tanks positioned along the access road. In both investigations sampling was performed with stainless steel scoops and sample increments were of the top 2 cm.

Table 2 shows the results for the samples collected in the impact area. Consistent with the findings of the Phase II study, HMX concentrations were higher than any of the other energetic residues on this impact range. Moreover, both investigations established the same order of energetic residue concentrations, HMX > NG > TNT > RDX > 2-ADNT and 4-ADNT. HMX concentrations in the eight replicates taken to represent the non-vegetated area around tanks 1 through 4 ranged from 270 to 1000 mg/kg and had a median of 430 mg/kg (mean and standard deviation 480±220 mg/kg). In 2003 [21], the HMX concentrations established for the same area (around tanks 1 through 4) ranged from 320 to 1300 mg/kg. Therefore, independent of the sampling design the same energetic residue concentrations were established near tanks 1 through 4. Moreover, the variation in concentration for HMX among the 8 replicates obtained for this study and those previously collected adjacent to the tanks, was a factor of 5 or less, showing a good reproducibility. This was also the case for HMX in the other duplicate and triplicate composite samples collected in the impact range during this investigation.

The secondary explosive in both the 66-mm M72 LAW rockets and the 84-mm HEAT rounds is Octol (70% HMX and 30 %TNT). As found previously at this site and on other antitank ranges, concentrations of TNT were generally two orders of magnitude lower than the HMX [4,5,18,29]. For example, the median concentrations of TNT and HMX were respectively 1.2 and 430 mg/kg for the eight sample replicates collected around tanks 1 through 4 (Table 2). The much lower concentrations of TNT than what would be anticipated based on the composition of Octol were attributed to fate and transport properties of TNT compared to HMX [18]. NG was also present, showing a median concentration of 26 mg/kg (mean and standard deviation 34±21 mg/kg) for the eight replicates of the samples around tanks 1 through 4. NG is present in the propellant for the M72 LAW rockets and the 84-mm rounds. NG that is not consumed during flight is dispersed upon detonation. Since both the Octol and the propellant are components of these rounds, the energetic residues should be dispersed in similar patterns. Indeed, the concentrations of HMX, TNT, and NG show a statistically significant correlation (95% the confidence level) among the 8 sample replicates, indicating that these energetic residues were co-located in this stratum. Moreover, because 2-ADNT and 4-ADNT are break down products of TNT, they were correlated with TNT and with one another. Explanations for the presence of RDX are that it may be in the booster of LAW rockets or it is from the blow-in-place of UXOs with blocks of C4.

The HMX concentration in the triplicate samples from the strafed area behind the tanks ranged from 17 to 37 mg/kg; 52 and 61 mg/kg in the duplicate samples from the vegetated area just north of tank 1; and 240 to 550 mg/kg in the vegetation between tanks 2 and 3. The HMX concentration in the duplicate samples collected in front of tank 6 were 94 and 130 mg/kg. The previous study established the HMX concentration at 81 mg/kg around tank 5 [21]. Results suggest that tanks 1 through 4, which are closest to the firing point, are the most heavily used targets on this range. Overall, this observation also is consistent with earlier studies of antitank ranges that have shown that HMX concentrations decrease rapidly with distance from targets [4,5,18,29].

Both investigations obtained a profile sample in front of tank 2. The profile sample collected during the initial investigation went to a depth of only 10 cm and was collected about 1 m from the tank. In 2002, at this location the concentrations of HMX, TNT, and NG were greater at the 5 to 10 cm interval than in the top 2 cm, and the report recommended that a deeper profile sample be collected to further investigate this trend. During the 2003 investigation, the sampling location used previously (on the edge of the road just in front of the tank) for a profile sample was disturbed from detonations as evidenced by the presence of subsurface debris (casing fragments). Moreover, gravel was encountered at a depth of about 15 cm, which inhibited any further subsurface penetration. Therefore, the location for the collection of a profile sample (Table 2) was moved to about 3 m in front of tank 2, between the two pools of water. At this location, digging a pit was much easier and no disturbance of the soil profile was evident (i.e., no subsurface debris was encountered). The profile concentrations of HMX, TNT, and NG all showed a decreasing trend with depth. For HMX more than a three order of magnitude decrease in concentration was observed from the surface to a depth of 28 cm. HMX was not detected in the deepest interval sample (28 to 31 cm). TNT (and its breakdown products, 2-ADNT and 4-ADNT) and NG were respectively, detected to depths of 19 cm and 14 cm. HMX is the least soluble and the most recalcitrant of these three energetic compounds to degradation [11,19]. Therefore, at this location, the resistance to biological degradation seems to play a more important role than solubility with regards to fate and transport.

The sediment and water samples taken from the pools of water in front of these four tanks contained detectable levels of HMX and NG; however, TNT was consistently detected in the sediment samples only (Table 3). The concentration of HMX in the sediments ranged from 9.0 to 640 mg/kg and in the water from 0.016 to 0.57 mg/L. Likewise, the NG concentrations in the sediments ranged from 8.0 to 110 mg/kg and in the water from 0.002 to 1.8 mg/L. These shallow pools of water contained several deeper pockets of water. Poor circulation between these pockets may account for the wide range of aqueous HMX and NG concentrations. HMX was also present in surface water samples collected on the CFB-Valcartier antitank range.

At the firing point on this range samples were collected in front of and behind the firing line. Both investigations determined that the samples collected behind the firing line generally had the highest NG concentrations (Table 4). During the initial investigation a single composite sample with a NG concentration of 11,000 mg/kg was collected between 0 and 2 m behind the firing line [21]. For this investigation several samples were collected in this same general area. Three separate composite samples collected immediately behind each of the concrete firing pads had NG concentrations that ranged from 28 to 610 mg/kg. Duplicate composite samples taken from 1 to 2 m behind the firing line contained 4,200 and 6,600 mg/kg. Taking into consideration the different areas sampled, the findings are consistent between the two investigations. In addition, during this investigation composite samples were collected out to a distance of 50 m behind the firing line and in areas that were designated as buffer zones (Figure 5). Overall, the NG decreased with distance behind the firing line, ranging from concentrations the in the thousands of mg/kg near the firing line to tens of mg/kg at 50 m (Table 4). This trend is consistent with other studies of firing points at antitank ranges [24, 26]. Moreover, composite samples that were collected over larger areas

(e.g., 0 to 20 m and 20 to 50 m) behind the firing line were within a factor of five the average of the composite samples from subsamples within these areas. Other than the decreasing trend moving behind the firing line, the different areas, failed to provide any additional information with respect to the distribution of NG.

Duplicate composite samples were collected in the south buffer zone. A single composite collected in the north buffer zone was split into two sections, separating the surface from the subsurface at the root zone. One of the composite samples in the south buffer zone had the highest concentration of NG found on this site; 17,000 mg/kg. Concentrations of NG in the other two surface buffer zones, 1,900 and 840 mg mg/Kg, south and north, respectively, were more consistent with the range of concentrations determined directly behind the firing line. In the north buffer zone the subsurface composite sample had a concentration of 490 mg/kg. The two buffer zones were located north and south of the firing line (each side) from 0 to 10 m away from the firing line.

Both investigations established the same concentrations of NG in front of the firing line. In addition, similar to behind the firing line, the concentrations decreased with distance. For example, surface samples collected along linear transects of 10, 20 and 50 m showed NG concentrations of 420, 65, and 14 mg/kg for the samples collected in 2002, and were 290 (mean of replicates), 77, and 20 mg/kg in the 2003 samples. The agreement between these two sets of sample results suggests that NG has not increased on the surface over the past year.

During this investigation samples were collected both in specified rectangular areas and along linear transects. Both sampling designs established the same concentration gradient moving away from the firing line. In addition, eleven duplicate samples were collected near the firing point on this range. In 9 out of 11 cases the concentrations established for NG were within a factor of 4 of each other, and in the other two cases the difference between the duplicates was greater than a factor of 5 but less than an order of magnitude. Since the NG is imbibed in NC, the comparison of field sample replicates could be confounded by the error associated with the laboratory preparation and sub-sampling of this sample matrix (see Appendix 3). Results form both investigations (2002 and 2003) demonstrated that most of the contamination was located behind and each side of the firing line. In fact, concentrations ranging over 1000 ppm of NG, and reaching peaks of 17,000 ppm (1.7 % w/w) were detected in a rectangular area starting from the firing line (plus 20 m each side), within a 20-m width behind the firing line.

Profile samples were collected 10 m in front of and behind the middle of the firing line. In both cases NG was detected in the samples collected at the deepest interval (63 cm) (Table 5). In front of the firing line, NG was still present at a depth of 57 cm below the surface; behind the firing line it was present at a depth of 63 cm. In both locations a mean concentration of 15±5 mg/kg was established for the surface profile discrete samples. These concentrations were well below what was established for the composite samples collected to represent these areas (i.e., approximately 200 of mg/kg in front and 4000 mg/kg behind). Based on the average surface concentration in both of these areas the NG concentrations had deceased by approximately four orders of

magnitude from the surface to the deepest profile sample. Even though this is a large decrease in concentration, the presence of NG at these depths suggests that either migration is rapid and/or that limited microbiological activity is limited. Laboratory studies have reported the half-live of NG to be less than a day [10].

4.4 New Castle Hand Grenade Range

The results for the linear transect and area composite samples collected at the hand grenade range are presented in Table 6. This is a new range that has been in use for almost two years. Range control stated that 2459 M67 hand grenades were detonated on this range since its opening, meaning approximately 1200 grenade fired per year. The M67 hand grenade contains 183 g of Composition B (60% RDX and 40% TNT). We can then extrapolate that 270 kg of RDX and 180 kg of TNT were detonated in the past 2 years. There were a few trace level concentrations of TNT (<0.005 mg/kg) detected in the samples collected during this investigation, and a single trace level (0.010 mg/kg) detection of RDX in the samples collected during the previous investigation. This confirms that when hand grenades are fired under a high order detonation process, very little contamination occurs. Much higher concentrations of these two energetic residues would be present if even a single hand grenade had under gone a low-order or partial detonation during a training exercise or blow-in-place operation [23, 30].

Both investigations determined that NG and 2,4-DNT were present in all the surface samples collected on this range. These two compounds are typically associated with propellant residues. The same sampling design was used during both investigations for collecting composite samples along linear transects at distances of 10, 20, 30, 40 and 50 m from the throwing bays (Figure 14). For this investigation the NG and 2,4-DNT ranged from 0.094 to 0.42, and from 0.002 to 0.50 mg/kg, respectively (Table 6). These levels of energetic residue concentrations were about the same as had been established the previous year (NG 0.043 to 0.20 mg/kg and 2,4-DNT 0.006 to 0.061 mg/kg). Previously, the presence of these two energetic compounds was attributed to a pre-existing range condition, as a result of being a rebound area for major live-five impact range [21].

In addition to collecting samples along linear transects several were collected over rectangular areas. The range of concentrations for NG and 2,4-DNT in the area composite samples were similar to those collected along linear transects. Four duplicate samples were collected on this range. In 2 of the 4 duplicates the discrepancy in concentration of one analytes detected exceeded an order of magnitude. The variability between the duplicates most likely is a function of the generally low concentrations and/or the error associated with the laboratory preparation and subsampling of sample matrices containing energetic compounds often associate with propellant residues (see Appendix 3).

4.5 40-mm New Castle Rifle Grenade Range

Range control was able to provide us with the number of rifle grenades fired on the range since its opening: 1206 grenades. Composite samples were collected in rectangular areas (approximately 30 x 25 m) near two sets of targets that were positioned at two different distances from the firing point (Figure 15, Table 7). Near the first set of three targets, between 100 and 130 m from the firing point, RDX, NG and 2,4-DNT were detected at low concentrations (<0.2 mg/kg). The previous investigation, also established the presence of NG and 2,4-DNT at or below 0.2 mg/kg in this general area. Since this range is next to the New Castle Hand Grenade range, and was constructed at the same time, the presence of NG and 2,4-DNT was attributed a pre-existing range condition [21]. Further down range at distance between 170 and 200 m from the firing point HMX, RDX, and NG were detected. Near the target on the left side of the range at this distance, the concentration of RDX was 0.5 mg/kg. The detection of RDX on this range is consistent with the main charge in 40-mm rifle grenades, which is Composition B. Moreover, since RDX had not been detected previously, this energetic residue may have just started to build-up on the surface over the past year. Only a single sample duplicate was obtained on this range, using the same sampling strategy as used at the firing point. In this case the concentrations of RDX, HMX, and NG established for sample duplicates were within a factor of two of each other. The situation in the rifle grenade was similar to the hand grenade where almost no residues of RDX or TNT were detected even though more than 1200 grenades have been fired on the range since its opening.

4.6 Blow-in-place Locations

4.6.1 Blow-in-place of two 84-mm antitank rounds

Prior to the demolition operation the surface samples from within the ordnance disposal bunker showed that HMX, NG, TNT, and two of its break down products, 2-ADNT and 4-DNT were present (Table 8). In these pre-demolition samples the HMX concentrations did not exceed 0.6 mg/kg, TNT was less than 0.08 mg/kg, and NG did not exceed 20 mg/kg. The blow-in-place of the two 84-mm HEAT rounds formed two small blacken craters (70 cm diameter, 20 cm deep). HMX, TNT and NG were detected in every post-detonation sample. In addition, RDX was present in the crater samples and in one of the duplicates collected within the 1 m diameter circle. Overall, HMX ranged from 30 to 120 mg/kg (median 82 mg/kg), TNT ranged from 1.8 to 34 mg/kg (median 6.1 mg/kg), and NG ranged from 9.7 to 110 mg/kg (median 38 mg/kg) in the post-detonation samples. The two orders of magnitude increase in the concentrations of HMX and TNT can be attributed to the Octol in HEAT rounds. Since similar levels of energetic residues were found in both craters, it was anticipated that both rounds contributed to the buildup of energetic residues. The much smaller increases seen for NG indicate that this energetic compound was efficiently consumed. Residues of RDX can be attributed to the blocks of C4 used for this demolition operation.

The ratio of the median post-blast concentrations of HMX to TNT was 13, which is about an order of a magnitude smaller than the median radio of these two energetic compounds in the samples taken around tanks 1 through 4 (HMX/TNT; 430/1.2), which was 360. The findings associated with the blow-in-place of these rounds support the concept that TNT is more efficiently consumed than HMX during detonation. However, consumption during detonation cannot fully account for the discrepancy in concentration that exists between these energetic residues on antitank impact ranges. Therefore, a shorter residence time for TNT on surface, presumably because of its relatively high water solubility is also a factor [18].

Duplicate samples were taken before and after this blow-in-place operation. For all of these composite samples the increments were collected within relatively small areas (e.g., 3-m^2 area and 1 m diameter circle). In almost every case the concentrations for HMX, TNT, and NG in the sample duplicates were within a factor of 4 of each other. The one case that failed to meet this criterion was prior to detonation when TNT was only present at trace levels (<0.08 mg/kg) in one of the samples.

4.6.2 Blow-in-place of 500 LB bomb

The samples that were collected prior to the detonation of the 500 LB bomb showed the presence of trace quantities (<0.05 mg/kg) of RDX, TNT and TNB (Table 9). Previously collected samples in a different region of this range showed the presence of trace quantities of RDX and 2,4-DNT [21]. Following the blow-in-place of this bomb with 3 blocks of C4, NG was detected in every surface sample and trace quantities of RDX and TNT were sporadically detected. These findings show the energetic compounds in the main charge in the bomb and the demolition blocks of C4 were efficiently consumed in the detonation. NG, which ranged from 0.014 to 3.4 mg/kg in the post-blast samples, presumably came from the fuze or booster of this bomb. Two triplicate and one duplicate sets of samples were obtained following the detonation. All of these sets of replicates had at least one analyte that either was not detected on the other replicates or showed a large discrepancy in concentration. With the exception of one high NG concentration, the remaining values were at trace levels (< 0.055 mg/kg). As before when mostly low energetic residue concentrations exist (in this case for NG, TNT, and RDX) the precision among the field sample replicates, was much poorer than for moderate (>0.2 mg/kg) to high levels. Considering the fact that the 500 pounds bomb contained a large quantity of TNT, results demonstrate that the BIP operation was successful, leading to a high order event and only traces of explosive residues in the BIP crater.

4.7 Burning Pads

Results from both 2002 and 2003 campaigns are presented in table 10. In 2002, burning locations number one and two were sampled and showed residues of 2,4-DNT

in all samples in concentrations up to 32 ppm. Other target analytes, 2,6-DNT, TNT, RDX and tetryl were also detected. No NG was detected, indicating that only single based propellant was burned in the two locations. The sampling conducted in 2003 encompassed four burning locations. For burning locations one and two, we can see a clear trend for 2,4-DNT which goes from 17 ppm to 491 ppm around Pad 1A and from 32 to 57.7 ppm around Pad 1B. Location 2B presented lower concentrations in 2003 for 2,4-DNT. In general Location 3 presented low levels of contamination while Location 4B presented 60 ppm of 2,4 DNT and small concentrations of NG; therefore, double or triple based propellant might have been burned on this specific location. The highest concentration detected was at Pad 1A with 491 ppm, then Pad 4B at 60.4 ppm and Pad 1B at 57.7 ppm of 2,4-DNT. Traces of NG were detected at Location 4B as well.

4.8 Analysis of Sampling Strategies

When comparing the sampling results for 2002 and 2003, we can conclude that independently of the sampling designs and strategies used for collecting composite surface samples, the same energetic residue concentrations were established on three different ranges CFB, Gagetown. This phenomenon can be directly related to the use of composite sampling. As an example, both Phases II and III studies demonstrated that in the impact zone on the Wellington antitank range HMX exists at 100 to 1000s of mg/kg and likewise NG exists at these concentrations and higher around the firing point. In 2003, the sampling pattern encompassed wider area than in 2002 but results between the two Phases are comparable.

Most composite samples collected in phase III were representative of a specified area, whereas in Phase II linear transects were used. Both sampling designs were able to establish the presence of energetic residues, their respective concentrations, and their spatial distribution. Advantages of using rectangular areas as opposed to a linear transect, are that area based concentrations are established and this design is more likely to encounter hot spot(s) than linear transects. Also, they allow the potential calculation of total quantity of contaminants in specific areas, when the surface concentration, depth profile and soil density are know. In the present study, this calculation was not possible, based on the high uncertainty of the concentrations with depth. Only a limited number of depth profiles were collected which did not allow the calculation of a reliable concentration with depth for the sampled area. In the future, we recommend using the collection of samples within surfaces representative of a specified area instead of linear transects. We also recommend collecting many sub-surface samples to assess the variation of concentration with depth and allow the calculation of the overall mass of contaminant.

To assess the ability to collect representative composite samples, several replicates were obtained in 2003 using both areas and linear transects sampling designs. In all cases, the increments obtained to comprise the composite samples were collected using a systematic or systematic/random sampling strategy. That is, the sampling area or transect was defined and increments were either collected at a pre-selected frequency or randomly as the collector proceeded from one end to the other. In all instances,

these sampling strategies avoid sampling the same location more than once. Using these strategies, the replicate field samples agreed within a factor of 5 or less when energetic residues or heavy metals were present at moderate (>0.2 mg/kg) or higher concentrations. In a previous study, 30-increment composite samples were collected in two separate 10 x 10-m locations on an artillery impact range [25]. In both of these sampling areas chunks of TNT residue that were initially present on the surface, were removed prior to sampling. Each composite sample was obtained using a totally random technique to obtaining the increments. That was the direction and distance between sampling points changed between the collection of each increment. In both cases the range of TNT concentrations among the sample replicates exceeded a factor of two orders of magnitude (0.019 to 3.12 mg/kg and 0.11 to 69.9 mg/kg). Based on this comparison, the more systematic approach to obtaining increments appears to result in more reproducible field samples. One explanation for this discrepancy between sampling strategies is that hot spots are more likely to be missed or re-sampled using the totally random approach to collecting increments. Two benefits of taking a composite sample over a larger area are that it reduces the number of samples that need to be processed and analyzed and establishes an average concentration. However, if analyte concentrations in sample replicates fail to agree reproducible, that is, are not within an order of magnitude or less, then the error associated with compositional or distributional heterogeneity are not being adequately addressed. Based on the findings in this study, a systemic approach to building a composite sample for a given area either addresses or is less susceptible to these two sources of error.

5. Results and Discussion – Metals

The concentration and distribution of heavy metals was not clearly delineated in the 2002 study. We wanted to learn more about metals mobility and fate in the environment and about their evolution in concentrations with time, one year later. In order to learn more about metals mobility and leachability, depth profiles were collected at two locations in the anti tank range and leachate tests [34] were conducted (EPA 1311) on heavily contaminated samples. All results discussed in section 5 are presented in Table 11 (See attached CD).

5.1 Background Samples

As stated in section 3.1, another set of background samples was collected to verify the presence/absence of TNT residues that had been problematic in 2002. Metals were analyzed for all background samples collected in 2003 in order to obtain a higher number of representative background sample and extrapolate a better mean background value for comparison with values obtained in the training ranges. Results are presented in Table 11a. Results obtained in 2002 are highlighted in yellow, while the one obtained in 2003 are in blue. Mean background values were calculated as for last year by adding the average value obtained for all samples plus twice the standard deviation attached to the mean value. We are aware that this method is not a valid approach on a purely statistical point of view. However, it is a very good and simple means to measure trends in the firing range and highlight the analytes that will have to be monitored in the long term in the live-fire area where metals are accumulating and might exceed the criteria. Table 11 a presents the calculated mean background value for all analytes (MBG) and also the Canadian Council of the Ministry of the Environment (CCME) Industrial Soil Quality Guidelines (ISQG) (www.ccme.ca). Industrial quality guidelines were selected as more applicable to the context of a training area. In Table 11b to 11 j results that are higher than the MBG were highlighted in blue fonts, while the ones higher than the ISQG were highlighted in red fonts.

5.2 Wellington Anti-Tank Range samples

In Phase II, Cu, Ni and Zn exceeded the ISQG in all samples in target area. The following analytes exceeded the MBG: Ag, Ba, Bi, Ca, Cd, Cr, Mo, Pb, Sb, Sr and W. In the firing position (FP), no analytes exceeded the ISQG, while only a few exceeded the MBG, usually behind the FP (Cd, Cu, Mo, Ni, Pb, Sn and Sr) (Table 11 b).

In 2003, 107 samples were collected in the antitank range. In the target area (Table 11c), many soil replicates were collected to assess the variation between field replicates using multi-increment composites in the large sampling area. The following pairs of samples are actual field replicates (GAG 007-008, 009-010, 011-012, 013-014, 015-017, 018-019, 021-022 and 023-024). By comparing the results obtained for all analytes for all sets of replicates, we observe a very good reproducibility between field

replicates. Concentrations of metals showed a statistically significant correlation between field replicates. This indicates that our sampling approach led to representative results for metal analytes.

5.2.1 Target Area

Results obtained in the target area, demonstrated that the soils were impacted with Cu, Ni and Zn at levels higher that the ISQG respectively for 100, 50 and 10% of all samples collected. Copper was the most problematic analyte, with levels as high as 25 times the ISQG. Many other metal analytes accumulated over the MBG concentrations and should be monitored in the future. The following metal analytes were over the MBG in the target are (within brackets: percentage of samples higher than the MBG): Ag (100%), Ba (70%), Bi (100%), Cd (100 %), Cr (90%), Mo (100%), Pb (100%), Sb (100%) and Sn (100%).

Results are comparable to what was observed in 2002. Levels of Cu and some other analytes measured in 2003 were somewhat lower than in 2002 which can be explained by the fact that the sampling area chosen in 2003 was larger than in 2002 thus “diluting” the concentration by sampling an area farther from the tank targets. In both campaigns, levels of concern of copper were found in all target samples and Ni and Zn exceeded the ISQG in many samples.

Eight sediment samples were collected in ponds located between targets one and two and two and three (Table 11e, GAG 137 to 144). This set of samples had high concentrations of several metals of concern. In particular, the levels of copper were very high, the highest being 10,600 mg/Kg, which is almost a hundred times the ISQG. All of the sediment samples had levels of Cu higher than the ISQG. In addition, other parameters exceeded the ISQG. They were As, Cr, Ni, Pb and Zn. Finally, almost all other analytes of concern were higher than the MBG. The ponds are the most contaminated area of the range from an heavy metal perspective. The ponds are formed by accumulation of run off water from nearby targets. Definite build up of contaminants is taking place in these locations.

In order to assess the fate of antitank range munitions related contaminants, a pit was dug in front of tank target Number 2 for profile sampling. The results are presented in Table 11 e. Levels of Cu higher than the ISQG were obtained from the surface layer to a depth of 20 cm with successively decreasing levels, to a layer where the concentration was higher than the MBG at a depth of 19-26 cm. The concentrations became equal to lower than the MBG until a 31 cm depth. All parameters higher than the ISQG or MBG showed a similar trend with decreasing concentrations from the surface to depth, reaching values equal to lower than the MBG at a depth of approximately 20 cm. This indicated that for most of the metal analytes, the contamination was found only in the top 20 cm of surface soil, and not much migration either as fine particles or dissolved species deeper than 20 cm was allowed. Tin, which was present at levels of approximately 8 times the MBG in all profile samples was an exception. Tin is either more mobile or is naturally occurring in this range at a higher level than in the surrounding training area. Tin is not regulated under CCME, so this is not of a high concern at the present time.

5.2.2 Firing Position

In 2002, only four samples were collected in the FP area. High levels of propellant residues were detected in these samples; therefore, further sampling was conducted in this area in 2003. Results obtained in 2002 indicated that a few metal analytes exceeded the MBG (Cd, Cu, Mo, Ni, Pb, Sn and Sr) without reaching CCME SQG concentrations. This was confirmed in 2003 with detections slightly over the ISQG for Cu and Ni in two samples out of 34 (Table 11d). Although higher than MBG, results for metals in front of and back of the FP are not of concern since they are relatively low and probably will not reach levels of concern in the future. The two hits over the ISQG, were not consistent with their soil replicates; therefore, the replicates means did not exceed the ISGQ.

Results obtained for the depth profiling in the FP area are presented in Table 11 f. Two pits were dug 10 m in front and behind the FP. Only a few detections exceeded the MBG. No correlation with the depth of sampling was observed. These results confirm the ones obtained for the surface samples at the FP, with no problems associated with heavy metals. No levels of lead higher than the MBG have been detected in the profile samples, in contrast to the results obtained for the surface samples. However, higher levels of lead were found on the soil surface farther in the front of the FP, starting at a distance of 20 meters from the FP. Stable higher levels of tin were observed in all profile samples, which might indicates that tin is naturally occurring at a higher level in this particular geological formation. Representative background samples could be collected around this specific area to validate this hypothesis, but since it is not a high concern, there is no reason at this time to proceed.

5.3 New Castle Rifle Grenade Range Samples

Results from the 2002 and 2003 campaigns for the Rifle Grenade range are presented in Table 11g. Results from the 2002 campaign were highlighted in yellow, while the ones from the 2003 campaign were in blue. This range is relatively new and not much training has been held there since its opening two years ago. Only one hit was observed over the ISQG for copper, which was a very localised and small impact. Four other analytes were detected at concentrations slightly higher than the MBG (Pb, Sn, Sr, Tl). At the present time, no action is required base on these results. A monitoring program including these analytes every five years would be necessary to follow the situation and assess if the concentrations would reach levels of concerns with time.

5.4 New Castle Hand Grenade Range (NCHGR) Samples

Results from the 2002 and 2003 campaigns for the Hand Grenade range are presented in Table 11g. Results from the 2002 campaign were highlighted in yellow, while the

ones from the 2003 campaign were in blue. The 2003 campaign involved the collection of more samples to cover a larger sampling area to better delineate the extent of contamination outside the visible boundaries of the range. This was decided in 2002 based on the extensive detection of munition related contaminants found in the area. Evaluate of the evolution of the situation one year after the first sampling event was also of interest. When we compare the results from 2002 and 2003 for the same locations for all analytes, the parameters that were of concern in 2002, Cu, Pb and Zn, still exhibit higher levels in 2003. Both Cu and Zn levels have increased by approximately 30 %. Zn was already higher than the ISQG last year in most samples, which was still the case in 2003 with one sample more (40 m in front of the bunker) presenting levels higher than ISQG. Copper concentrations are increasing, while still under the ISQG. Lead concentrations were stable when compared to last year. Levels of Sn have increased by a factor of 20 between the two sampling events. This parameter should then be included in the surveillance program. The new area sampled outside of the range boundary both on the left, right and far end of the range did not show concentration of concern of heavy metals, except for the first 0 to 5 m area on the left side, which presented residues of zinc at higher than ISQG concentration. The hand grenade range presented levels of concern of zinc on all the surface of the range until 40 m away from the bunker and 5 m each side from the bunker width. This means that an overall surface of 65 m by 40 m contains levels of Zn higher than the ISQG and levels of Cu, Pb and Sn higher than the MBG. These parameters should be re-assessed in the future.

When we compare the results obtained in the Gagetown hand grenade range to the ones obtained for the hand grenade range in Shilo [2, 3], we observe that levels of heavy metals are lower in Gagetown than in Shilo. This was not surprising considering the fact that the Gagetown range is only two years old, while the Shilo range has been in operation for more than 20 years. Nevertheless, the same parameters of concern arose in both ranges; Cu, Pb and Zn. In Shilo, Cu levels are approximately 10 times higher (ranging from 91 to 779 ppm) and Zn results are approximately 4 times higher (ranging from 1180 to 2400 ppm). Higher levels of Cd were also detected in Shilo, which might be attributed to the use of German grenade on this range. Mg levels were also of concern in Shilo, which might be attributed to the use of flare grenades. The results obtained in the Shilo and Gagetown hand grenade ranges are logical, complementary and related to the intensity of the past training conducted at each range.

5.5 Blow-in-Place Locations

Metals were analyze prior and after the BIP of two types of items to verify if BIP can lead to detectable augmentations of heavy metals analytes in the BIP area.

5.5.1 Blow-in-place of two 84-mm antitank Heat rounds

In 2002 the EOD bunker located on the anti tank range (Figure 5) was sampled to assess if the blow in place activity lead to the spreading of munitions related residues in the surface soil. At that time only one composite

from the bottom and the walls of the surrounding berms was collected, S-WAT-OD Pit (Table 11b). Only Cu was detected in a concentration slightly over the MBG concentration, which indicated a limited impact of the blow in place activity. In 2003 two 84-mm rounds were blown in place by the EOD teams. Four soil samples were collected in the bottom of the pit before (GAG 012-024) and after (GAG 025-028) the detonation. In addition, two samples were collected in each crater after the BIP (Table 11 c). Results showed that three metal analytes were detected over the MBG in the bottom of the pit; Cd, Cu and Sn. If we look at the results before and after the detonation, we can see that for most of the analytes, the concentrations remained stable at the exception of Cd, Cu and Sn where higher levels were detected after detonation of the rounds, especially in the two samples collected in both craters. An impact could then be measured even for the BIP of small items such as 84-mm heat. This conclusion is not based on a sufficient number of trials and samples and should be verified by conducting other trials.

5.5.2 Blow-in-place of 500 LB bomb

As explained earlier, soil samples were collected before and after the detonation of a 500-lb bomb in the Hersey range. All soil samples were analyzed for metals in order to learn about the impact of such a large calibre blow in place on the spreading of metal in the surrounding area. Obviously, metals can be expected to be spread in the environment by a blow in place exercise, but the extent to which this would be measurable was unknown. The potential dilution factor created by the expansive dispersion of the detonation plume may be significant. The results are presented in Table 11h. A measurable impact was observed. In the pre-blast samples, some hits over the MBG were detected for Ba, Cd, Cu, Mn, Pb, Sn and Sr. The highest hit was for Pb at 208 ppm. These high concentrations might result from the leaching of metal particulates from the bomb casing, or from past firing activities in the Hersey range. The parameter exceeding the MBG were also detected over this limit in most samples collected last year in the Hersey range, thus supporting the second hypothesis. The following analytes were higher post-blast than pre-blast: (in brackets by how much percent compared to pre-blast): Al (33%), Ba (25%), Be (50%), As (33 %), Ca (25%), Co (60 %), Cr (100%), Fe (100 %), Li (80 %), Mg (100 %) and Mn (30%). This was the first time that the localized impacts of blow in place operation have been documented from a metals perspective. Even if the detonation plume was quite wide for such a large item, a distinct trend was still seen for many analytes. This would have to be confirmed in other trials, but these first results are still of interest. When we observe which analytes were added to the site, some are obviously from the casing or the primer (Al, Cr, Fe, Mg and Mn) while others are less obviously related to the munition that was detonated. The soil profile is heavily disturbed in such events and some analytes may have come from the mixing of the soil profile and the presence of higher levels in the deeper soil layers.

5.6 Burning Pads

Results from both Phases II and III at burning pad locations are presented in Table 11i. In 2003 four burning location were sampled compared to 2 in 2002. Results obtained in 2002 were highlighted in yellow and in 2003 in blue. In 2002 two parameters were of concern: Pb and Sr. This was expected considering the fact that some gun propellant bags contain Pb as a lubricating agent for the gun barrel. Sr might come from the burning of flares on the concrete pads. These trends were confirmed in 2003 with the accumulation of much higher levels of Pb. Values near 60,000 ppm, were measured around the concrete Pad number 1. Levels of Sr also increased to almost 6000 ppm. Sr is not regulated by CCME but such high levels are still of concern. Concrete pads one and two have obviously been used more extensively than other pads, and presented levels over the ISQG for Pb on the surface soil around the pads. Pads one and two should, therefore, be cleaned up; the soils around each pad should be collected and sent to an appropriate landfill.

5.7 Vimy Small Arms Range

Results from both Phases II and III are presented in Table 11j. In 2003, samples were collected both in the target area and in the firing line positions to assess the contamination by heavy metals on the firing lines. Three main parameters exceeded CCME ISQG: Pb, Cu and Sb. This is directly related to the small arms munitions composition where the casing is made of copper and the filling is made of lead and antimony. The lead contains 2% by weight of antimony to give more stiffness to the composition. [35]. The concentrations of lead detected from 2002 to 2003 increased by factors varying from 1.5 to 234. The ratio between antimony and lead was smaller than 2%, potentially indicating a higher leaching rate of antimony than lead. The depth samples also contained high levels of heavy metals. Levels of Ca, Na and K were not as high as the ones detected in Shilo Small arms ranges [2, 3], which is fortuitous. When high concentrations of these analytes are found in the soils, wildlife grazes preferentially on contaminated vegetation.

Some parameters were higher than the MBG concentration: Ag, As, Mn, Mo, Sn, Sr, Tl, and Zn. These are either associated with illumination rounds fired on the range or with impurity present in the conventional rounds. The same parameters have been detected over the MBG in Shilo and Valcartier small arms ranges, but not at levels of concern when compared to Cu, Pb and Sb [2, 3, 6].

Finally, in Table 11 j, the residential soil quality guideline (RSQG) for lead has been taken into account since on the firing lines, military people lie down on the soil surface while firing their weapons. This scenario is better represented by residential guidelines than industrial guidelines. When Pb concentrations detected in the firing line were compared to the RSQG, the concentrations were higher than the threshold at the 100 and 300 m lines. This situation should be examined by health experts to determine if the exposure of the military leads to a health risk, based on the frequency of firing at these locations.

5.8 TCLP testing

Based on the high levels of Pb detected in 2002, in 2003, leaching tests were conducted on the soils collected both in the small arms range and in the propellant burn area. The Environmental Protection Agency (EPA) Toxicity Characteristic Leaching Procedure (TCLP) test number 1311 [34] was used. This is a stringent test. In the U.S.A., when soil samples exceed 5 ppm of lead, the soil must be managed as a hazardous waste. The TCLP is designed to mimic condition of leaching over an extended period of time. It identifies the long-term leachability of heavy metals [34, 35]. EPA Regulatory levels for leachates, Environment and Fauna Quebec regulatory levels for leachate testing of dangerous goods and Transport Canada, TCLP levels for hazardous materials are presented in Table 12 for comparison. Interestingly, 2,4-DNT is regulated in Canada and in the USA as *dangerous goods leachates*. Soils are not regulated by TCLP in Canada, only dangerous goods are. However, results of the TCLP on heavily contaminated soil samples represent a mean to verify their long-term leachability potential.

5.8.1 Vimy Small Arms Range

Results of the TCLP test on the small arms range samples are presented in Table 11k. Results indicated that Pb had the potential for leaching to the ground water table with levels as high as 1440 ppm of dissolved Pb in soil leachate. Interestingly, the highest hit was observed for a depth sample, which might indicate that the lead species found in deeper layers on the target area are more soluble and are slowly moving to deeper layers of soils and will eventually reach the ground water table. No threshold criteria exist for antimony, but levels of 3 ppm were detected in some leachates, indicating that Sb is leachable as well.

5.8.2 Burning Pads

Results of the TCLP tests on the burning pads areas are presented in Table 11l. The same tendency for lead as observed in the small arms range was observed, but to a lesser extent, with concentrations of lead as high as 428 ppm in the soil leachate collected around Pad 1B. Results obtained for the leachates correlated those obtained in the soil samples. Higher levels of strontium were observed in the soil samples and were reflected in the leachate results where a concentration of 13 ppm was obtained for the soil leachate coming from the Pad 3A. Both lead and strontium detected in soil around the Gagetown burning pads possess long-term leachability potential.

6. Conclusion

6.1 Summary of 2002 results

General conclusions from the Phase II study are that the Anti-Armour Range and Wellington Antitank Rocket Range are impacted by various heavy metals and explosive residues, both at level of concerns. The most contaminated areas were found near targets, and to the front and rear of firing positions. Artillery ranges were mainly impacted by Cd, Cr, Zn and Pb but in localized target area. Metals were also detected in high concentrations at target areas or in craters in artillery impact areas. The contaminants of concerns in the artillery ranges are Cd, Cu and Zn. Argus range presented the highest concentrations of metals followed by Lawfield, Hersey and Greenfield Impact Areas. Explosive residues were detected at lower concentrations on artillery ranges than on the Anti-Armour Range and Wellington Antitank Rocket Range. Grenade ranges also presented mixed contamination by both metals and energetic materials with the oldest range being the mostly highly impacted area. The burning area had high concentrations of Pb, Sr and 2,4-DNT as expected, since burning of propellants is known to be an incomplete process that leads to the accumulation of propellant residues in the environment. Finally, small arms ranges (SAR) were heavily impacted by lead and other heavy metals. In general, trends that were identified for soil accumulation were correlated with vegetation results for the 2002 study.

Results of the 2002 study led to the following objectives for 2003: to further develop our understanding of the spatial distribution of metals and explosives on five live fire ranges, to assess vertical migration of metals and explosives and to verify the presence/absence of explosive residues in background samples.

6.2 2003 Study

In 2003, additional background samples were collected. Results of metal analytes obtained in the live fire area were compared to both the calculated mean background value for all analytes (MBG) [21] and also to the Canadian Council of the Ministry of the Environment (CCME) Industrial Soil Quality Guidelines (ISQG). The collection of supplementary background samples demonstrated that the detection of TNT observed in 2002 was caused by cross-contamination between samples, as no TNT was detected in any samples in 2003.

As per the sampling strategies used in the Phase III study, it appears that a systemic approach to building a composite sample for a given area proved to be less susceptible to sources of error. Two benefits of taking a composite sample over a larger area are the reduction of the number of samples that need to be processed and analyzed and establishment of a more representative average concentration. The approach improves the estimation of the total amount of contaminants per stratum.

6.3 Wellington Antitank Range

Results for heavy metals are comparable to those observed in 2002. In the target area, Cu, Ni and Zn were detected at levels higher that the ISQG respectively for 100, 50 and 10% of all samples collected. Copper was the most problematic analyte with levels as high as 25 times the ISQG. The following metals were also accumulated in the target area: Ag, Ba, Cd, Cr, Mo, Pb, Sb, and Sn. Results for energetic residues confirm what was observed in 2002 with levels of HMX as high as 1040 mg/kg in the target area and much lower concentrations of TNT and RDX. Surface soils in the target area were mainly impacted by HMX, Cu, Ni and Zn.

Three profile samples were obtained on the Wellington antitank range. In each case the energetic residue present in the highest concentration at the surface was still detectable near or at the bottom of the profiles. In the future even deeper profile samples should be obtained to further investigate the migration of energetic residues. In the target area the profile concentrations of HMX, TNT, and NG all showed a decreasing trend with depth. HMX concentrations decreased by three orders of magnitude from the surface to a depth of 28 cm. HMX is the least soluble and the most recalcitrant of these three energetic compounds. Resistance to biological degradation seems to play a more important role than solubility in HMX transport. A very interesting progression with depth was also observed for heavy metals. Concentrations of Cu higher than the ISQG were obtained in the surface layer and decreased with depth to levels equal to or lower than the MBG. Global results for all metal analytes indicated levels of concern primarily in the top 20 cm of surface soil with little migration deeper than 20cm.

The analysis of sediment and water samples from ponds in the target area showed energetic residues and heavy metals, at higher concentrations than in the surrounding surface soils. The ponds are formed by water run off near targets, in depression areas. Results indicated a build up of contaminants in these locations. Variable concentrations of energetic residues were detected in the surface waters, demonstrating that the ponds are non homogeneous. Results varied by more than one order of magnitude depending where the sample was collected within a pond. In the future, co-located water and sediment sample should be obtained to help explain the wide range of concentrations within contiguous bodies of water. Moreover, these findings suggest that surface runoffs should be controlled on antitank impact ranges to prevent offsite migration of munition related contaminants.

In the firing position, results obtained in 2002 were confirmed. No metal analytes exceeded neither the MBG nor any SQG. However, concentrations of NG were over 1000 ppm, reaching peaks of 17,000 ppm (1.7 % w/w) in a rectangular area starting from the firing line (plus 20 m on each side), with a 20-m width behind the firing line. NG was detected in profile samples even at the deepest sampled layer collected in front of and behind the middle of the firing line. The presence of NG at these depths suggests that either migration is rapid and/or that microbiological activity is limited.

That might be explained by the fact that NG is embedded by nitrocellulose, is stable and it moves. Therefore, vertical migration of NG is definitely a threat to ground water.

6.4 Hand and Rifle Grenade Ranges

Results obtained in 2003 at the New Castle Hand Grenade range demonstrated no evidence of a build up of energetic residues associated with the current training practices performed at this facility, even though approximately 1200 grenade were fired annually for the last two years. A few trace level concentrations of TNT (<0.005 mg/kg) were detected in the samples collected during this investigation, and a single trace level (0.010 mg/kg) of RDX was detected in the samples collected during the previous investigation. This confirms that when hand grenades detonate properly (i.e., high order detonation), very little residue remains. Phases II and III investigations determined that NG and 2,4-DNT were present in all the surface samples collected on this range. These two compounds are typically associated with propellant residues and were associated with past use of this area. As for heavy metals, the hand grenade range present levels of concern for zinc in all of the surface soil samples of the range, until 40 m away from the bunker and 5 m on each side of the bunker. This means that an overall surface of 65 m by 40 m presented levels of Zn higher than ISQG and levels of Cu, Pb and Sn higher than the MBG. When compared to the Shilo hand grenade range, the levels of contamination were lower, but showed an increase from 2002 and 2003. Heavy use of the range, with approximately 1200 grenades per year, could lead to the build up of concentrations higher than the ISQG for other parameters than Zn, such as Cu, Sn and Pb.

The rifle grenade range is also relatively new and is larger than the hand grenade range. Therefore, the build up of concentrations will take a longer time. Only one sample exhibited a concentration over the ISQG for copper. Four other analytes were detected at concentrations slightly higher than the MBG (Pb, Sn, Sr, Tl). As for energetic materials, a slight build up (0.5 mg/kg) of RDX was observed near the targets. This may be attributed to munitions currently being trained with at this facility. At the present time, no actions are required base on these results.

6.5 BIP Locations

Results before and after the detonation of the two 84-mm rounds showed that for most of the metal analytes the concentrations remained stable with the exception of Cd, Cu and Sn, where slightly higher levels were detected after detonation. The blow-in-place of these rounds also elevated the surface concentrations of both HMX and TNT. Past studies have shown a potentially wide range in the mass of energetic residues contributed to the environment from replicate blow-in-place operations using identical protocols. Therefore, additional trails should be performed prior to drawing any inferences from the demolition of these two munitions. However, these findings support the contention that if the same location is used repeatedly for demolition operations, the build-up of energetic residues and metals is very likely to occur.

For the BIP of the 500-lb bomb filled with Tritonal, no appreciable increase in the concentration of TNT in either the crater or on surrounding soil surface was observed. Considering the fact that the 500 pound~~s~~ bomb contained a large quantity of TNT, results demonstrate that the BIP operation was a successful high order event and only left traces of explosive residues in the BIP crater. However, the post-blast samples results showed the following analytes: Al, Ba, Be, Co, Cr, Fe, Li, Mg and Mn. This was the first documentation of the localized impact~~s~~ of blow in place operation by metals. Even if the detonation plume was quite wide for such a large item, a distinct trend was seen for many analytes. This would have to be confirmed with additional trials.

6.6 Burn Pads

The main contaminants detected at BP locations were 2,4-DNT, lead and strontium. The most highly contaminated were pad 1A with 491 ppm, then pad 4B with 60.4 ppm and pad 1B with 57.7 ppm of 2,4-DNT. Traces of NG were detected at location 4B as well. This tendency was the same for lead and strontium. Leachate testing of the BP soil samples demonstrated that on a long-term basis, both lead and strontium have the potential for migrating to the ground water table. Concrete pads one and two have obviously been used more extensively, presenting levels over the ISQG for lead on the surface soil around the pads. A decision was recently made to stop using these pads which were jugged non efficient, and the surface soils around the pads should be collected and sent to an appropriate landfill.

6.7 Vimy SAR

Three metal concentrations exceed CCME and ISQG; lead, copper and antimony. This is directly related to the small arms munitions composition where the casing is made of copper and the filling is made of lead and antimony. We can see a progression in the concentrations detected between 2002 and 2003 with an increase in levels of lead by factors varying from 1.5 to 234. The ratio between antimony and lead was smaller than what would be expected based on the small arms composition, potentially indicating a higher leaching rate for antimony than lead. Levels of Ca, Na and K were not as high as the ones detected in Shilo Small arms ranges [2, 3]. The lower concentrations for these analytes suggest limited attraction of the wildlife to graze preferentially on the contaminated vegetation.

In 2003, firing lines were sampled to verify lead build up due to the known presence of lead in the primers. Results were compared to the CCME residential soil quality guidelines since they are more appropriate to the situation of soldiers lying down on these soils. In the 100 and 300 m distance lines, the concentrations detected were higher than the CCME threshold. This situation should be examined, based on the frequency of firing at these locations.

Results for lead indicated a potential for leaching to ground water with levels as high as 1440 ppm of dissolved lead in soil leachate. Interestingly, the highest concentrations was observed for a depth sample, which suggest that the lead species found in deeper

layers on the target area are more soluble and are slowly moving to deeper layers of soils and will eventually reach the ground water. No threshold criteria have been established for antimony. Therefore, the significance of the levels of 3 ppm of antimony detected in some leachates is uncertain.

6.8 Surface results versus ground water results

The Gagetown training area was also the subject of a detailed hydrogeologic study [20]. The quality of the ground water was verified by drilling many wells across the training area. Several wells in the Bivouac area demonstrated higher levels than the MBG for some metals analytes, which were not related to the training activity. For all wells located in the area near where we detected higher levels of either heavy metals or energetic materials in the surface soils, no correspondence was measured in the corresponding ground water samples. As an example, despite the fact that high concentrations of HMX and NG were detected in the surface of the WAT and that sub-surface migration have been observed for both compounds (Appendix 4), no explosive residues were detected in the ground water down-gradient of the AT range. This means that only limited migration has taken place and that the explosives have not reached the ground water.

This is a very important overall conclusion of this study. Until now, munition-related contaminants have not reached the ground water. Results of limited TCLP testing on highly contaminated soils, and results from profile samples indicated a risk of migration of contaminants. Therefore, a long-term surveillance program should be put into place.

Based on the overall results obtained in all surface and ground water field work, the authors of the present report in collaboration with INRS scientists will draft an action plan for the Gagetown training area that will help mitigate the potential adverse impacts and support the sustainable live-fire training.

7. Figures

Figure 1. Gagetown Area Map

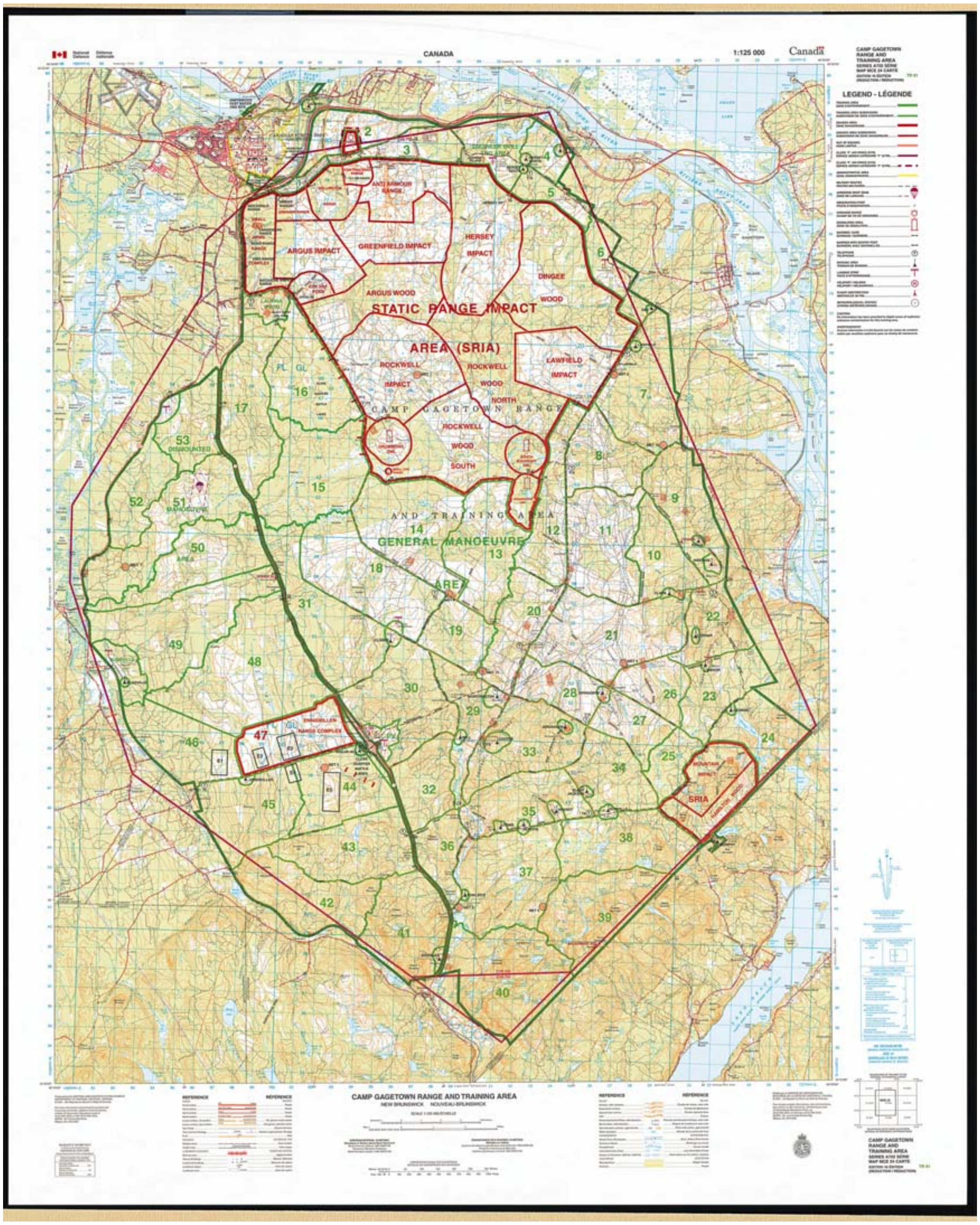

Figure 2. Gagetown Training Area Map

Figure 3. Core sampler

Figure 4. Target # 2, WAT Range

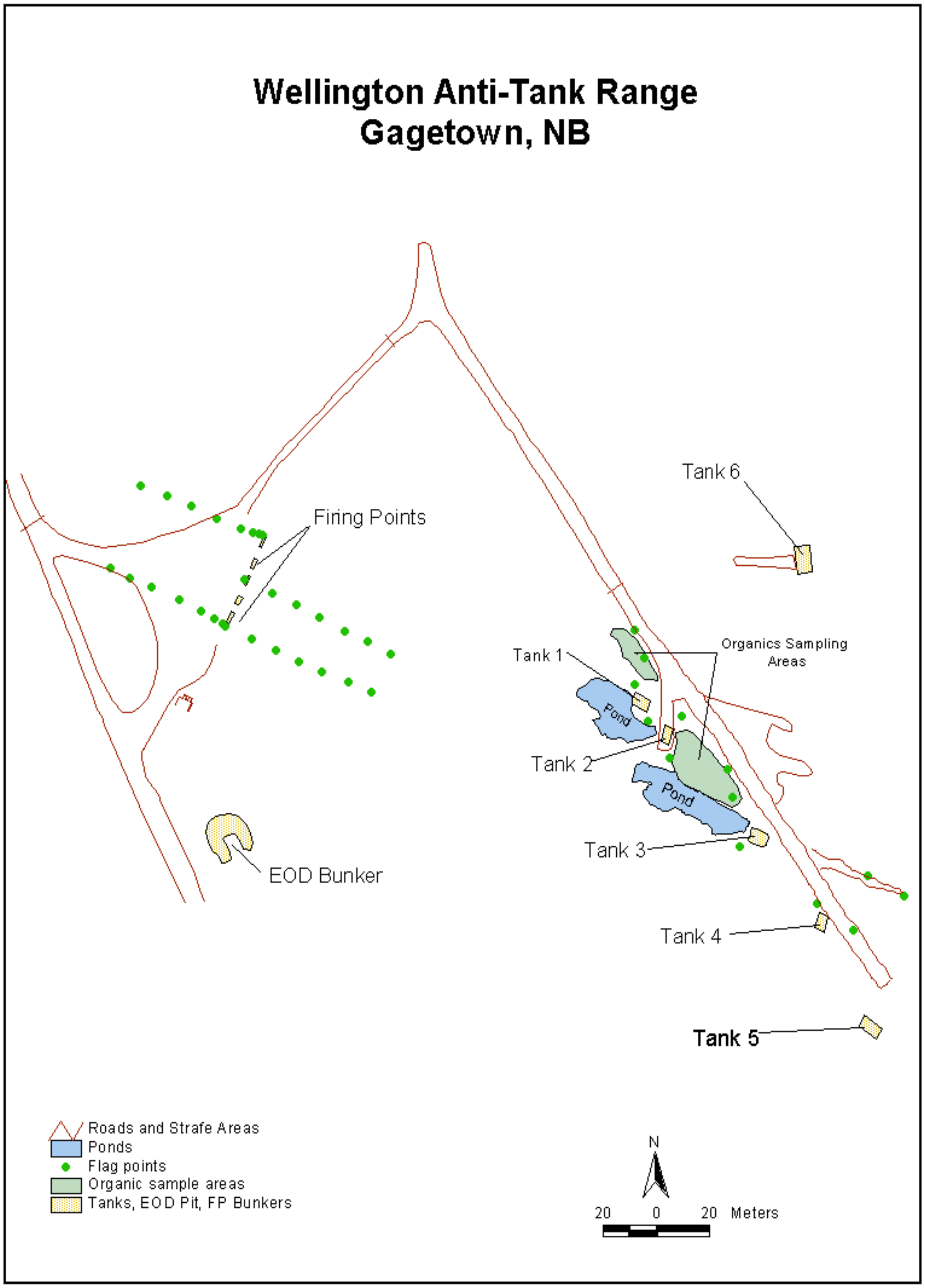

Figure 5. WAT Range

Figure 6. Digging for depth sampling profiling

Figure7. Depth profiling in anti-tank firing position

Figure 8. 84-mm rounds that were blown in place in WAT EOD bunker

Figure 9. 84-mm round with one C4 block before BIP

Figure 10. Crater formed after the blow in place of 84 mm HEAT round

Figure 11. Fixed firing positions, Wellington Antitank range

Figure 12. Depth profiling, at the rear of the firing line, Wellington ATR

Figure 13. Depth profiling, at the front of the firing line, Wellington ATR

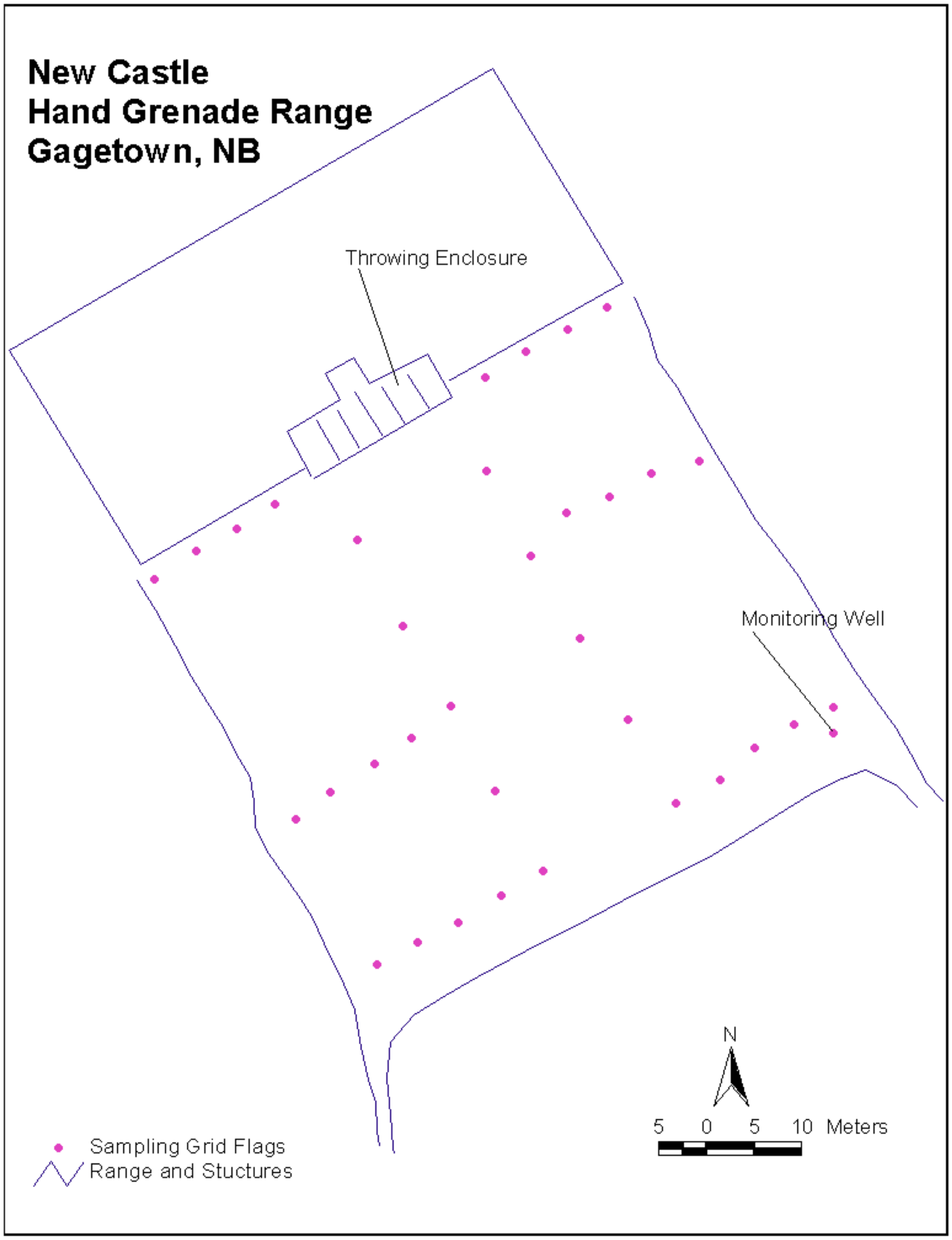

Figure 14. New Castle Hand grenade range sampling pattern

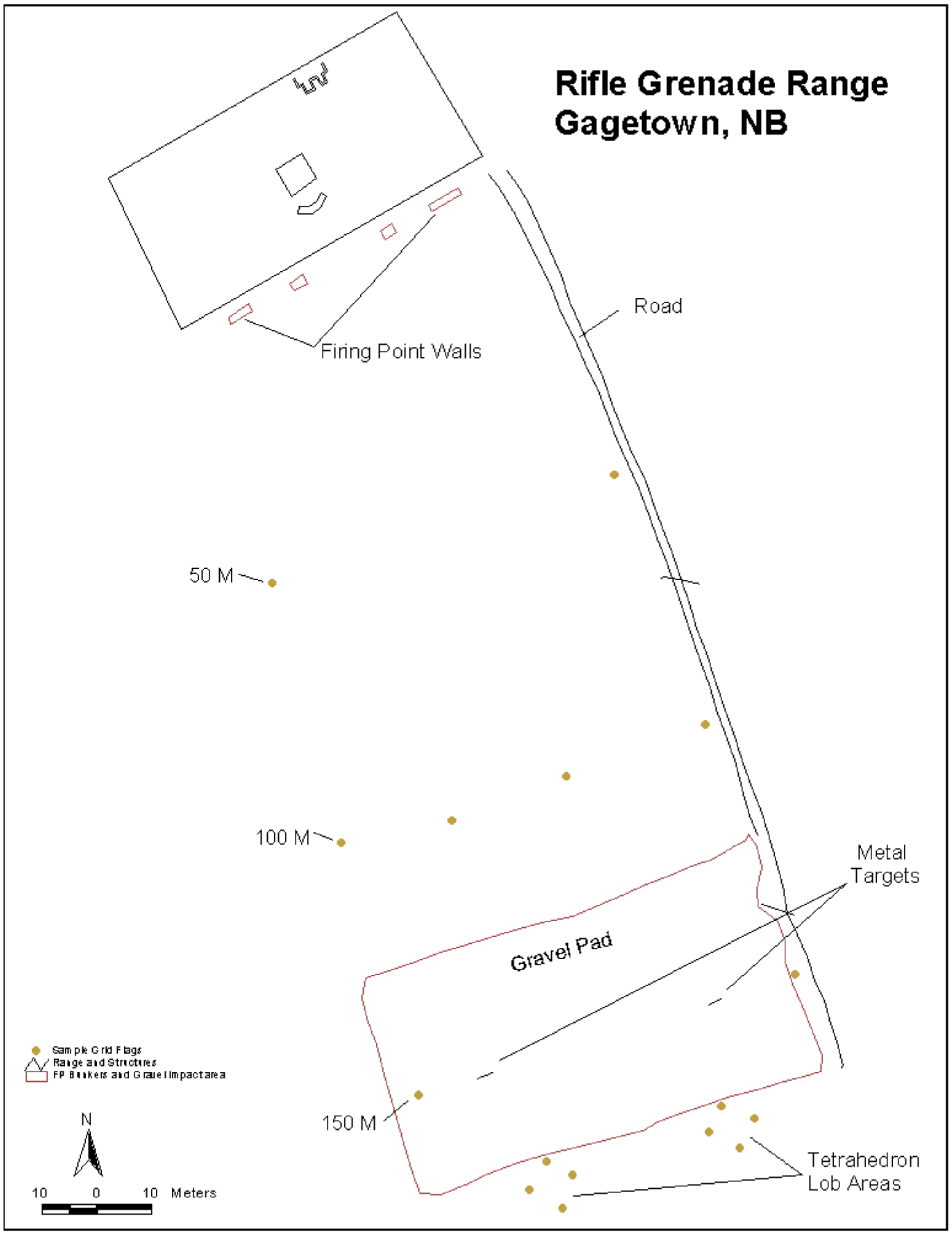

Figure 15. New Castle Rifle Grenade Range sampling pattern

Figure 16. 500-lb bomb, with broken tail fens, Hersey range.

Figure 17. Crater from the BIP of the Mk82 500 LB bomb, Hersey range

Figure 18. Propellant burning pad 1A

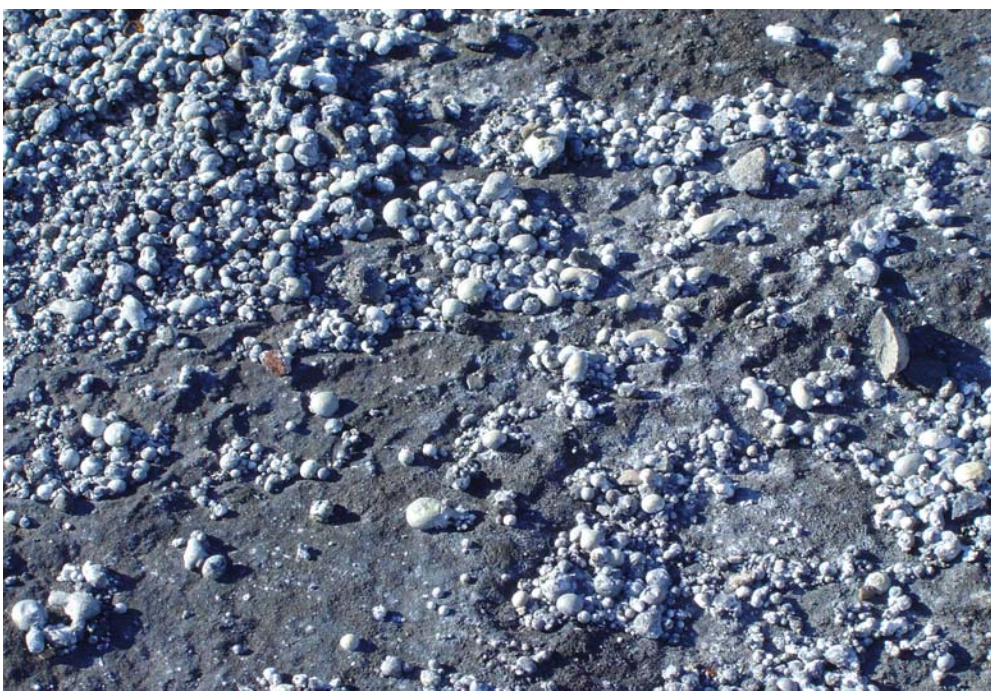

Figure 19. Melted propellant residues, Pad 1a.

Figure 20. Propellant burning pad 2A

Figure 21. Propellant burning pad 4A

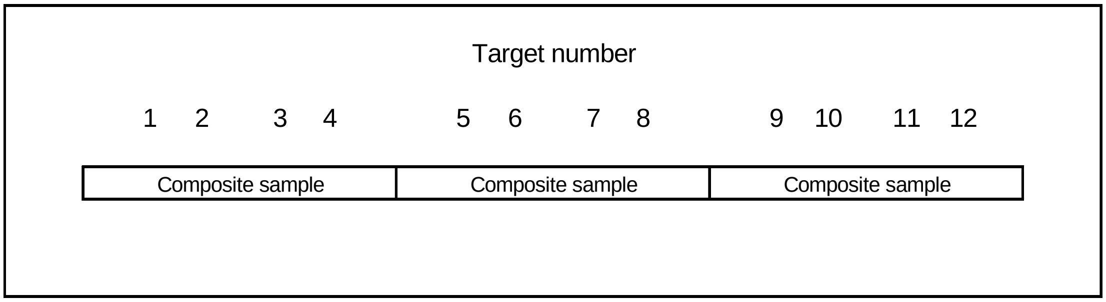

Figure 22. Sampling pattern used in Vimy Small Arm Range. Composite sampling locations relative to numbered targets.

8. Tables

All tables are included on the CD attached to this report. Table 1 to 10 present the results obtained for explosive analysis either by GC/ECD or HPLC. Table 11 a to 11 l present the results obtained for metal analyses. Table 12 present the sample logs while table 13 present TCLP Thresholds. The following tables can be retrieved from the CD:

TABLE 1. CONCENTRATION OF EXPLOSIVES IN BACKGROUND SAMPLES

TABLE 2. CONCENTRATION OF EXPLOSIVES IN SAMPLES COLLECTED AROUND TARGETS AT THE WELLINGTON ANTITANK RANGE.

TABLE 3. CONCENTRATION OF EXPLOSIVES IN SEDIMENT AND WATER SAMPLES COLLECTED IN POOLS IN FRONT OF TARGETS AT WELLINGTON ANTITANK RANGE.

TABLE 4. CONCENTRATION OF EXPLOSIVES IN FIRING POINT SAMPLES AT WELLINGTON ANTITANK RANGE.

TABLE 5. CONCENTRATION OF EXPLOSIVES IN PROFILE SAMPLES COLLECTED IN FRONT AND BEHIND FIRING POINT AT WELLINGTON ANTITANK RANGE.

TABLE 6. CONCENTRATION OF EXPLOSIVES IN NEW CASTLE HAND GRENADE RANGE SAMPLES.

TABLE 7. CONCENTRATION OF EXPLOSIVES IN NEW CASTLE RIFLE GRENADE RANGE SAMPLES.

TABLE 8. CONCENTRATION OF EXPLOSIVES FROM SAMPLES COLLECTED BEFORE AND AFTER THE BLOW-IN-PLACE OF 84-MM ANTITANK ROUNDS AT WELLINGTON DEMOLITION BUNKER.

TABLE 9. CONCENTRATION OF EXPLOSIVES BEFORE AND AFTER THE BLOW-IN-PLACE OF A 500LB BOMB ON THE HERSEY IMPACT RANGE.

TABLE 10. CONCENTRATION OF EXPLOSIVES IN SAMPLES COLLECTED IN BURN PAD LOCATIONS.

TABLE11. CONCENTRATION OF METALS FOR ALL SOIL SAMPLES.

TABLE 12. TCLP THRESHOLD: EPA FOR SOILS AND ENVIRONMENT AND FAUNA QUÉBEC REGULATORY LEVELS FOR DANGEROUS GOODS.

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List of Symbols/Abbreviations/Acronyms

BG	Background Sample
BIP	Blow in Place
CCME	Canadian Council of Ministers of Environment
CFB	Canadian Forces Base
CRREL	Cold Regions Research and Engineering Laboratory
DLE	Directorate Land Environment
DND	Department of National Defense
DNT	Dinitrotoluene
DRDC	Defense Research and Development Canada
EOD	Explosive Ordnance Disposal
FP	Firing Position
GC/ECD	Gas Chromatograph/Electron Capture Detector
GPS	Global Positioning System
ICP/MS	Inductively Coupled Plasma/Mass Spectrometry
NCHGR	New Castle Hand Grenade Range
NCRGR	New Castle Rifle Grenade Range
NG	Nitroglycerine
OB/OD	Open Burning/Open Detonation
QA/QC	Quality Assurance/Quality Control
RPD	Relative Percent Difference
SAR	Small Arms Range
RSQG	CCME Residential Soil Quality Guideline
TCLP	Toxicity Characteristic Leaching Procedure
TNT	2,4,6-Trinitrotoluene
UXO	Unexploded Ordnance
WAT	Wellington Anti Tank Range

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Appendix 1. Sample log, CFB Gagetown October 2003				
Lab ID	Tag Label	Date Collected	Notes	Range
GAG001	Tanks Chuck 44 incs	37914	Composite sample from road and pads next to tank targets.	Wellington
GAG002	Tanks Chuck 46 incs	37914	Composite sample from road and pads next to tank targets.	Wellington
GAG003	Tanks Alan 44 incs	37914	Composite sample from road and pads next to tank targets.	Wellington
GAG004	Tanks Alan 44 incs	37914	Composite sample from road and pads next to tank targets.	Wellington
GAG005	Tanks Sonia 44 incs	37914	Composite sample from road and pads next to tank targets.	Wellington
GAG006	Tanks Sonia 44 incs	37914	Composite sample from road and pads next to tank targets.	Wellington
GAG007	Tanks Marianne 44 incs	37914	Composite sample from road and pads next to tank targets.	Wellington
GAG008	Tanks Marianne 44 incs	37914	Composite sample from road and pads next to tank targets.	Wellington
GAG009	Tank 1 Organic Chuck 32 incs	37914	Composite sample of surface organics near tank #1 target	Wellington
GAG010	Tank 1 Organic Chuck 33 incs	37914	Composite sample of surface organics near tank #1 target	Wellington
GAG011	Tanks 2 to 3 Organic Chuck 29 incs	37914	Composite sample of surface organics between tanks #2 and #3 targets	Wellington
GAG012	Tanks 2 to 3 Organic Chuck 31 incs	37914	Composite sample of surface organics between tanks #2 and #3 targets	Wellington
GAG013	Tank 5 Trench Chuck 35 incs	37914	Composite sample from trench in front of Tank #5	Wellington
GAG014	Tank 5 Trench Marianne 30 incs	37914	Composite sample from trench in front of Tank #5	Wellington
GAG015	Tanks Strafe Area Chuck 40 incs	37914	Composite sample from strafed area beyond road	Wellington
GAG016	Tanks Strafe Area Alan 33 incs	37914	Composite sample from strafed area beyond road	Wellington
GAG017	Tanks Strafe Area Marianne 40 incs	37914	Composite sample from strafed area beyond road	Wellington
GAG018	Tanks Road Only Chuck 48 incs	37914	Composite sample from road next to tank targets	Wellington
GAG019	Tanks Road Only Chuck 45 incs	37915	Composite sample from road next to tank targets	Wellington
GAG020	Tanks "plateau" area Chuck 30 incs	37915	Composite sample from plateau area near tank	Wellington
GAG021	Before BIP 84-mm Chuck Rep 1 14 incs	37915	Horse-shoe shaped area used for BIP	Wellington
GAG022	Before BIP 84-mm Chuck Rep 2 14 incs	37915	Horse-shoe shaped area used for BIP	Wellington
GAG023	Before BIP 84-mm Guy Rep 1 30 incs	37915	1-m diameter circle between rounds	Wellington
GAG024	Before BIP 84-mm Guy Rep 2 30 incs	37915	1-m diameter circle between rounds	Wellington
GAG025	After BIP 84-mm Chuck Rep 1 14 incs	37915	Horse-shoe shaped area used for BIP	Wellington
GAG026	After BIP 84-mm Chuck Rep 2 14 incs	37915	Horse-shoe shaped area used for BIP	Wellington
GAG027	After BIP 84-mm Guy Rep 1 30 incs	37915	1-m diameter circle between rounds	Wellington
GAG028	After BIP 84-mm Guy Rep 2 30 incs	37915	1-m diameter circle between rounds	Wellington
GAG029	After BIP 84-mm Crater 1 Alan	37915	Crater from BIP (black residue)	Wellington
GAG030	After BIP 84-mm Crater 2 Alan	37915	Crater from BIP	Wellington
GAG031	Behind AT FP 0m-1m Rep 1	37915	S-WAT (0-1 Behind) (Soil-Wellington AntiTank)	Wellington
GAG032	Behind AT FP 0m-1m Rep 2	37915	S-WAT (0-1 Behind) (Soil-Wellington AntiTank)	Wellington
GAG033	Behind AT FP 0m-1m Rep 3	37915	S-WAT (0-1 Behind) (Soil-Wellington AntiTank)	Wellington
GAG034	Behind AT FP 1m-2m Rep 1	37915	S-WAT (1-2 Behind) (Soil-Wellington AntiTank)	Wellington
GAG035	Behind AT FP 1m-2m Rep 2	37915	S-WAT (1-2 Behind dupe) (Soil-Wellington AntiTank)	Wellington
GAG036	Behind AT FP 2m-5m	37915	S-WAT (2-5 Behind) (Soil-Wellington AntiTank)	Wellington
GAG037	Behind AT FP 5m-10m	37915	S-WAT (5-10 Behind) (Soil-Wellington AntiTank)	Wellington
GAG038	Behind AT FP 10m-20m	37915	S-WAT (10-20 Behind) (Soil-Wellington AntiTank)	Wellington
GAG039	Behind AT FP 20m-30m Rep 1	37915	S-WAT (20-30 Behind) (Soil-Wellington AntiTank)	Wellington
GAG040	Behind AT FP 20m-30m Rep 2	37915	S-WAT (20-30 Behind dupe) (Soil-Wellington AntiTank)	Wellington
GAG041	Behind AT FP 30m-40m	37915	S-WAT (30-40 Behind) (Soil-Wellington AntiTank)	Wellington
GAG042	Behind AT FP 40m-50m	37915	S-WAT (40-50 Behind) (Soil-Wellington AntiTank)	Wellington
GAG043	Behind AT FP 0m-20m Rep 1 37 incs	37915	Composite by Chuck	Wellington
GAG044	Behind AT FP 0m-20m Rep 2 35 incs	37915	Composite by Chuck	Wellington

GAG045	Behind AT FP 20m-50m Rep 1	37915	Composite by Chuck	Wellington
GAG046	Behind AT FP 20m-50m Rep 2	37915	Composite by Chuck	Wellington
GAG047	Behind AT FP South Buffer Rep 1	37915	Composite by Annie and Andre	Wellington
GAG048	Behind AT FP South Buffer Rep 2	37915	Composite by Annie and Andre	Wellington
GAG049	Behind AT FP North Buffer Biomass	37915	Composite with corer by Sonia and Guy. Top of core.	Wellington
GAG050	Behind AT FP North Buffer "Soil"	37915	Composite with corer by Sonia and Guy. Bottom of core.	Wellington
GAG051	Behind AT FP 20m-50m Road MEW	37915	Composite from gravel road at FP. Behind north firing positions.	Wellington
GAG052	Behind AT FP 20m-50m Veg Chuck	37915	Composite from vegeatation next to gravel road at FP. Behind north firing positior	Wellington
GAG053	Front AT FP 0m-10m	37915	S-WAT (0-10 FRONT) (Soil-Wellington AntiTank) (Alan and Guy)	Wellington
GAG054	Front AT FP 10m-20m Rep 1	37915	S-WAT (10-20 FRONT dupe) (Soil-Wellington AntiTank) (SONIA and TAR)	Wellington
GAG055	Front AT FP 10m-20m Rep 2	37915	S-WAT (10-20 FRONT dupe) (Soil-Wellington AntiTank) (SONIA and TAR)	Wellington
GAG056	Front AT FP 20m-30m	37915	S-WAT (20-30 FRONT) (Soil-Wellington AntiTank)(Alan and Guy)	Wellington
GAG057	Front AT FP 30m-40m Rep 1	37915	S-WAT (30-40 FRONT) (Soil-Wellington AntiTank) (SONIA and TAR)	Wellington
GAG058	Front AT FP 30m-40m Rep 2	37915	S-WAT (30-40 FRONT dupe) (Soil-Wellington AntiTank) (SONIA and TAR)	Wellington
GAG059	Front AT FP 40m-50m	37915	S-WAT (40-50 FRONT) (Soil-Wellington AntiTank)(Annie and Andre)	Wellington
GAG060	Front AT FP 50m-60m Rep 1	37915	S-WAT (50-60 FRONT) (Soil-Wellington AntiTank)(Alan and Guy)	Wellington
GAG061	Front AT FP 50m-60m Rep 2	37915	S-WAT (50-60 FRONT dupe) (Soil-Wellington AntiTank)(Annie and Andre)	Wellington
GAG062	Front 10m Line Rep 1	37915	Composite along line like last year. (SONIA and TAR)	Wellington
GAG063	Front 10m Line Rep 2	37915	Composite along line like last year. (SONIA and TAR)	Wellington
GAG064	Front AT FP 20m Line	37915	Composite along line like last year. (SONIA and TAR)	Wellington
GAG065	Front AT FP 50m Line	37915	Composite along line like last year. (SONIA and TAR)	Wellington
GAG066	500-lb Bomb Pre-Blast CAR MEW Surface	37916	5m to 20m from bomb marshy side 10 incs	Hersey
GAG067	500-lb Bomb Pre-Blast CAR MEW SubSurface	37916	5m to 20m from bomb marshy side 10 incs	Hersey
GAG068	500-lb Bomb Pre-Blast ADH TJ Surface	37916	5m to 10m from bomb 10 incs	Hersey
GAG069	500-lb Bomb Pre-Blast ADH TJ SubSurface	37916	5m to 10m from bomb 10 incs	Hersey
GAG070	500-lb Bomb Post-Blast Crater Wall CAR Rep 1	37916	63 incs approx approximately 1mX1m grid	Hersey
GAG071	500-lb Bomb Post-Blast Crater Wall CAR Rep 2	37916	67 incs approx approximately 1mX1m grid	Hersey
GAG072	500-lb Bomb Post-Blast Crater Wall CAR Rep 3	37916	66 incs approx approximately 1mX1m grid	Hersey
GAG073	500-lb Bomb Post-Blast Rim to 10m from edge ADH Rep 1	37916	________________	Hersey
GAG074	500-lb Bomb Post-Blast Rim to 10m from edge ADH Rep 2	37916	________________	Hersey
GAG075	500-lb Bomb Post-Blast Rim to 10m from edge ADH Rep 3	37916	________________	Hersey
GAG076	500-lb Bomb Post-Blast 10m to 20m from edge surface only MEW TJ	37916	25 incs using corer	Hersey
GAG077	500-lb Bomb Post-Blast 10m to 20m from edge surface only MEW TJ	37916	25 incs using corer	Hersey
GAG078	Castle Hand Grenade Range 10m Line (55m wide)	37916	S-NCHGR-10m 25 inc	"New" Castle
GAG079	Castle Hand Grenade Range 20m Line Rep 1	37916	S-NCHGR-20m 25 inc (SONIA)	"New" Castle
GAG080	Castle Hand Grenade Range 20m Line Rep 2	37916	S-NCHGR-20m 25 inc (TAR)	"New" Castle
GAG081	Castle Hand Grenade Range 30m Line	37916	S-NCHGR-30m 25 inc	"New" Castle
GAG082	Castle Hand Grenade Range 40m Line Rep 1	37916	S-NCHGR-40m 25 inc (SONIA)	"New" Castle
GAG083	Castle Hand Grenade Range 40m Line Rep 2	37916	S-NCHGR-40m 25 inc (TAR)	"New" Castle
GAG084	Castle Hand Grenade Range 50m Line	37916	S-NCHGR-50m 25 inc	"New" Castle
GAG085	Castle Hand Grenade Range Left 1 (0-5m)	37916	S-NCHGR-L1 30 inc	"New" Castle
GAG086	Castle Hand Grenade Range Left 2 Rep 1 (5-10m)	37916	S-NCHGR-L2 30 inc	"New" Castle
GAG087	Castle Hand Grenade Range Left 2 Rep 2 (5-10m)	37916	S-NCHGR-L2 (dup) 30 inc	"New" Castle
GAG088	Castle Hand Grenade Range Left 3 (10-15m)	37916	S-NCHGR-L3 30 inc	"New" Castle
GAG089	Castle Hand Grenade Range Left 4 (15-20m)	37916	S-NCHGR-L4 30 inc (TAR)	"New" Castle
GAG090	Castle Hand Grenade Range Right 1 Rep 1 (0-5m)	37916	S-NCHGR-R1 30 inc (TAR)	"New" Castle
GAG091	Castle Hand Grenade Range Right 1 Rep 2 (0-5m)	37916	S-NCHGR-R1 (dup) 30 inc(TAR)	"New" Castle

GAG092	Caslte Hand Grenade Range Right 2 (5-10m)		37916	S-NCHGR-R2 30 inc	"New" Castle
GAG093	Caslte Hand Grenade Range Right 3 (10-15m)		37916	S-NCHGR-R3 30 inc	"New" Castle
GAG094	Caslte Hand Grenade Range Right 4 (15-20m)		37916	S-NCHGR-R4 30 inc	"New" Castle
GAG095	Caslte Hand Grenade Range Rear (50-60m accross back of range, 55m wide)		37916	S-NCHGR-Rear 30 inc	"New" Castle
GAG096	Castle 40-mm Rifle Grenade Range Front of Target Right 100m - 130m		37916	S-NCRGR-Right 100m	"New" Castle
GAG097	Castle 40-mm Rifle Grenade Range Front of Target Center 100m - 130m		37916	S-NCRGR-Center 100m(Sonia)	"New" Castle
GAG098	Castle 40-mm Rifle Grenade Range Front of Target Left 100m - 130m		37916	S-NCRGR-Left 100m (TAR)	"New" Castle
GAG099	Castle 40-mm Rifle Grenade Range Behind Metal Plate Targets Right 170m - 200m		37916	S-NCRGR-Right 200m (TAR)	"New" Castle
GAG100	Castle 40-mm Rifle Grenade Range Behind Metal Plate Targets Center 170m - 200m		37916	S-NCRGR-Center 200m(Sonia)	"New" Castle
GAG101	Castle 40-mm Rifle Grenade Range Behind Metal Plate Targets Left 170m - 200m		37916	S-NCRGR-Left 200m(Annie)	"New" Castle
GAG102	Castle 40-mm Rifle Grenade Range Behind Metal Plate Targets Left 170m - 200m (D		37916	S-NCRGR-Left 200m (Dup)(Andre)	"New" Castle
GAG103	Wellington AT Range Background In Woods		37916	Collected by Alan	Wellington
GAG104	S-BG-00800-77309		37914	Background Samples Collected by Sonia and Guy	
GAG105	S-BG-01080-70413		37914	Background Samples Collected by Sonia and Guy	
GAG106	S-BG-03678-79720		37914	Background Samples Collected by Sonia and Guy	
GAG107	S-BG-03737-65708		37914	Background Samples Collected by Sonia and Guy	
GAG108	S-BG-07012-57921		37914	Background Samples Collected by Sonia and Guy	
GAG109	S-BG-08340-79797		37914	Background Samples Collected by Sonia and Guy	
GAG110	S-BG-12879-78123		37914	Background Samples Collected by Sonia and Guy	
GAG111	S-BG-14051-65600		37914	Background Samples Collected by Sonia and Guy	
GAG112	S-BG-15962-74801 REP 1		37914	Background Samples Collected by Sonia and Guy	
GAG113	S-BG-15962-74801 REP 2		37914	Background Samples Collected by Sonia and Guy	
GAG114	S-BG-17385-70972		37914	Background Samples Collected by Sonia and Guy	
GAG115	S-BG-18306-72076 REP 1		37914	Background Samples Collected by Sonia and Guy	
GAG116	S-BG-18306-72076 REP 2		37914	Background Samples Collected by Sonia and Guy	
GAG117	S-BG-97286-74154		37914	Background Samples Collected by Sonia and Guy	
GAG118	S-BP4A-0702632-5068613 AUTOUR		37914	Burn Pan Samples Collected by Sonia and Guy	
GAG119	S-BP4B-0702655-5068559 AUTOUR		37914	Burn Pan Samples Collected by Sonia and Guy	
GAG120	S-BP4B-0702655-5068559 CENTRE		37914	Burn Pan Samples Collected by Sonia and Guy	
GAG121	S-BP3A-0710300-5063140		37914	Burn Pan Samples Collected by Sonia and Guy	
GAG122	S-BP1A-0713612-5077219 AUTOUR		37914	Burn Pan Samples Collected by Sonia and Guy	
GAG123	S-BP1A-0713612-5077219 CENTRE		37914	Burn Pan Samples Collected by Sonia and Guy	
GAG124	S-BP1B-0713630-5077166 AUTOUR		37914	Burn Pan Samples Collected by Sonia and Guy	
GAG125	S-BP1B-0713630-5077166 CENTRE		37914	Burn Pan Samples Collected by Sonia and Guy	
GAG126	S-BP2B-0716505-5069160 AUTOUR		37914	Burn Pan Samples Collected by Sonia and Guy	
GAG127	S-BP2A-0716525-5069213 AUTOUR		37914	Burn Pan Samples Collected by Sonia and Guy	
GAG128	Tank #2 0 To 2.5 cm side wall		37914	Depth Profile Near Tank Target (TAR and ADH)	Wellington
GAG129	Tank #2 2.5 to 5 cm side wall		37914	Depth Profile Near Tank Target (TAR and ADH)	Wellington
GAG130	Tank #2 5 to 8 cm side wall		37914	Depth Profile Near Tank Target (TAR and ADH)	Wellington
GAG131	Tank #2 8 to 10 cm side wall		37914	Depth Profile Near Tank Target (TAR and ADH)	Wellington
GAG132	Tank #2 10 to 14 cm side wall		37914	Depth Profile Near Tank Target (TAR and ADH)	Wellington
GAG133	Tank #2 14 to 19 cm side wall		37914	Depth Profile Near Tank Target (TAR and ADH)	Wellington
GAG134	Tank #2 19 to 26 cm side wall		37914	Depth Profile Near Tank Target (TAR and ADH)	Wellington
GAG135	Tank #2 26 to 28 cm side wall		37914	Depth Profile Near Tank Target (TAR and ADH)	Wellington
GAG136	Tank #2 31 to 24 cm core bottom of hole		37914	Depth Profile Near Tank Target (TAR and ADH)	Wellington
GAG137	Tank #1 Sediment North side		37916	Sediment from Ponds near Tank Targets (TAR and ADH)	Wellington
GAG138	Tank #1 Sediment South side		37916	Sediment from Ponds near Tank Targets (TAR and ADH)	Wellington

GAG139	Tank #2 Sediment South side	37916	Sediment from Ponds near Tank Targets (TAR and ADH)	Wellington
GAG140	Tank #2 Sediment North Side	37916	Sediment from Ponds near Tank Targets (TAR and ADH)	Wellington
GAG141	Tank #3 Sediment North side, Close 5 ft	37916	Sediment from Ponds near Tank Targets (TAR and ADH)	Wellington
GAG142	Tank #3 Sediment South side 5 ft	37916	Sediment from Ponds near Tank Targets (TAR and ADH)	Wellington
GAG143	Tank #3 Sediment out at 26 to 28 ft	37916	Sediment from Ponds near Tank Targets (TAR and ADH)	Wellington
GAG144	Tank #3 Sediment out at 11,12,13 yards	37916	Sediment from Ponds near Tank Targets (TAR and ADH)	Wellington
GAG145	Center FP Wellington 10m Front 0 to 5 cm	37916	Depth Profile at Anti-tank FP (TAR and TJ)	Wellington
GAG146	Center FP Wellington 10m Front 5 to 7 cm	37916	Depth Profile at Anti-tank FP (TAR and TJ)	Wellington
GAG147	Center FP Wellington 10m Front 7 to 11.5 cm	37916	Depth Profile at Anti-tank FP (TAR and TJ)	Wellington
GAG148	Center FP Wellington 10m Front 11.5 to 13 cm	37916	Depth Profile at Anti-tank FP (TAR and TJ)	Wellington
GAG149	Center FP Wellington 10m Front 13 to 18 cm	37916	Depth Profile at Anti-tank FP (TAR and TJ)	Wellington
GAG150	Center FP Wellington 10m Front 18 to 22 cm	37916	Depth Profile at Anti-tank FP (TAR and TJ)	Wellington
GAG151	Center FP Wellington 10m Front 22 to 27 cm	37916	Depth Profile at Anti-tank FP (TAR and TJ)	Wellington
GAG152	Center FP Wellington 10m Front 27 to 31 cm	37916	Depth Profile at Anti-tank FP (TAR and TJ)	Wellington
GAG153	Center FP Wellington 10m Front 31 to 35 cm	37916	Depth Profile at Anti-tank FP (TAR and TJ)	Wellington
GAG154	Center FP Wellington 10m Front 35 to 39 cm	37916	Depth Profile at Anti-tank FP (TAR and TJ)	Wellington
GAG155	Center FP Wellington 10m Front 39 to 42 cm	37916	Depth Profile at Anti-tank FP (TAR and TJ)	Wellington
GAG156	Center FP Wellington 10m Front 42 to 47 cm	37916	Depth Profile at Anti-tank FP (TAR and TJ)	Wellington
GAG157	Center FP Wellington 10m Front 47 to 52 cm	37916	Depth Profile at Anti-tank FP (TAR and TJ)	Wellington
GAG158	Center FP Wellington 10m Front 52 to 57 cm	37916	Depth Profile at Anti-tank FP (TAR and TJ)	Wellington
GAG159	Center FP Wellington 10m Back 0 to 5 cm	37916	Depth Profile at Anti-tank FP (ALAN and TJ)	Wellington
GAG160	Center FP Wellington 10m Back 5 to 10 cm	37916	Depth Profile at Anti-tank FP (ALAN and TJ)	Wellington
GAG161	Center FP Wellington 10m Back 10 to 20 cm	37916	Depth Profile at Anti-tank FP (ALAN and TJ)	Wellington
GAG162	Center FP Wellington 10m Back 20 to 27 cm	37916	Depth Profile at Anti-tank FP (ALAN and TJ)	Wellington
GAG163	Center FP Wellington 10m Back 27 to 35 cm	37916	Depth Profile at Anti-tank FP (ALAN and TJ)	Wellington
GAG164	Center FP Wellington 10m Back 35 to 39 cm	37916	Depth Profile at Anti-tank FP (ALAN and TJ)	Wellington
GAG165	Center FP Wellington 10m Back 39 to 42 cm	37916	Depth Profile at Anti-tank FP (ALAN and TJ)	Wellington
GAG166	Center FP Wellington 10m Back 42 to 47 cm	37916	Depth Profile at Anti-tank FP (ALAN and TJ)	Wellington
GAG167	Center FP Wellington 10m Back 47 to 50 cm	37916	Depth Profile at Anti-tank FP (ALAN and TJ)	Wellington
GAG168	Center FP Wellington 10m Back 50 to 56 cm	37916	Depth Profile at Anti-tank FP (ALAN and TJ)	Wellington
GAG169	Center FP Wellington 10m Back 56 to 59 cm	37916	Depth Profile at Anti-tank FP (ALAN and TJ)	Wellington
GAG170	Center FP Wellington 10m Back 59 to 63 cm	37916	Depth Profile at Anti-tank FP (ALAN and TJ)	Wellington
GAG171	Crater (Demo action?), bottom and wall, random, 10 small scoops	37914	Crater on edge of road behind Tank#3 (TAR)	Wellington
Water samples				
1	4m in front of tank 1	37914	long narrow bands of water to 1+ feet deep in front of tanks (TAR)	Wellington
2	10m in front of tank 2	37914	long narrow bands of water to 1+ feet deep in front of tanks (TAR)	Wellington
3	3m in front of tank 2	37914	long narrow bands of water to 1+ feet deep in front of tanks (TAR)	Wellington
4	12+m in front of tank 3	37914	long narrow bands of water to 1+ feet deep in front of tanks (TAR)	Wellington
5	2m in front of tank 4	37914	long narrow bands of water to 1+ feet deep in front of tanks (TAR)	Wellington
6	in cater 15m out from front of tank 4	37914	long narrow bands of water to 1+ feet deep in front of tanks (TAR)	Wellington
7	surface water from pond	37916	~10m from 500lb. Bomb crater post blast. (CAR)	

Appendix 2-3: Detection limits and QA/QC sample results.

Sample #	Location	HMX	TNB	RDX	DNB	TNT	Tetryl	DNA	NG	2,4-DNT	2,6-DNT	2ADNT	4ADNT
		Soil concentration, mg/Kg											
RP-HPLC													
ERL		0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.080	0.080	0.080	0.080
LCS 1**		0.170	0.16	0.14	0.16	0.17	0.16	0.15	0.15	0.16	0.16	0.15	0.15
LCS 2		0.14	0.15	0.14	0.16	0.16	0.08	0.17	0.170	0.160	0.150	0.16	0.15
lab blk 1†		<d	<d	<d	<d	<d	<d	<d	<d	<d	<d	<d	<d
lab blk 2		<d	<d	<d	<d	<d	<d	<d	<d	<d	<d	<d	<d
GC-ECD													
ERL		0.03	0	0	0	0	0.020	0	0	0	0	0	0
lab blk 1		<d	<d	<d	<d	<d	<d	<d	<d	<d	<d	<d	<d
lab blk 2		<d	<d	<d	<d	<d	<d	<d	<d	<d	<d	<d	<d

Sample #	Location	HMX	TNB	RDX	DNB	TNT	Tetryl	DNA	NG	2,4-DNT	2,6-DNT	2-ADNT	4-ADNT
		Water concentration, mg/L											
LCS		0.22	0.200	0.21	0.21	0.19	0.11	--	--	0.2	0.2	0.2	0.2
lab blk		<d	<d	<d	<d	<d	<d	<d	<d	<d	<d	<d	<d

Recent Recovery - Soil

RP-HPLC												
LCS 1	102%	96%	86%	97%	99%	96%	93%	89%	96%	95%	90%	93%
LCS 2	87%	88%	86%	94%	95%	48%	99%	102%	96%	90%	95%	90%

Recent Recovery - Water

RP-HPLC												
LCS	109%	100%	104%	107%	97%	57%	--	--	102%	102%	102%	101%

* Estimated reporting limit
** Laboratory control sample
† Laboratory Blank

Appendix 2-3: Detection limits and QA/QC sample results.

Sample #		Soil concentration, mg/Kg											
		HMX	TNB	RDX	DNB	TNT	Tetryl	DNA	NG	2,4-DNT	2,6-DNT	2ADNT	4ADNT
G110		<d	<d	<d	<d	<d	<d	<d	0.01	<d	<d	<d	<d
110A		<d	<d	<d	<d	<d	<d	<d	0.01	<d	<d	<d	<d
110B		<d	<d	<d	<d	<d	<d	<d	0.02	<d	<d	<d	<d
	Average								0.0160				
	Std Dev.*								0.0035				
	%RSD**								21.7%				
G10		60.6	<d	0.07	<d	0.14	0.3	0.12	6.74	<d	<d	0.37	0.29
10A		61.4	<d	0.07	<d	0.26	0.32	0.12	4.16	0.06	<d	0.46	0.31
10B		60.6	<d	0.06	<d	0.12	0.36	0.13	6.48	<d	<d	0.41	0.35
	Average	60.8667		0.0667		0.1733	0.3253	0.1227	5.7933			0.4153	0.3160
	Std Dev.	0.4619		0.0042		0.0745	0.0336	0.0081	1.4205			0.0471	0.0269
	%RSD	0.8%		6.2%		43.0%	10.3%	6.6%	24.5%			11.3%	8.5%
G20		322	0.04	0.25	<d	10.8	<d	<d	35.2	0.05	<d	1.45	1.09
20A		328	0.04	0.26	<d	12.2	<d	<d	23	0.05	<d	1.40	1.07
20 B		314	0.04	0.26	<d	11.1	<d	<d	24	0.04	<d	1.42	1.08
	Average	321.3333	0.0407	0.2567		11.3667			27.4000	0.0480		1.4350	1.0800
	Std Dev	7.0238	0.0031	0.0031		0.7371			6.7735	0.0069		0.0212	0.0100
	%RSD	2.2%	7.5%	1.2%		6.5%			24.7%	14.4%		1.5%	0.9%
G40		<d	<d	<d	<d	<d	<d	<d	380	<d	<d	<d	<d
40A		<d	<d	<d	<d	<d	<d	<d	406	<d	<d	<d	<d
40B		<d	<d	<d	<d	<d	<d	<d	394	<d	<d	<d	<d
	Average								393.3333				
	Std Dev								13.0128				
	%RSD								3.3%				
G50		<d	<d	<d	<d	<d	<d	<d	494	<d	<d	<d	<d
50A		<d	<d	<d	<d	<d	<d	<d	494	<d	<d	<d	<d
50B		<d	<d	<d	<d	<d	<d	<d	478	<d	<d	<d	<d
	Average								488.6667				
	Std Dev								9.2376				
	%RSD								1.9%				
G60		2.9	<d	0.05	<d	0.07	<d	<d	44	0.1	0.2	<d	<d
60A		2.72	<d	0.05	<d	0.07	<d	<d	46.2	0.13	0.23	<d	<d
60B		2.72	<d	0.05	<d	0.07	<d	<d	44.2	0.13	0.19	<d	<d
	Average	2.7800		0.0467		0.0713			44.8000	0.1193	0.2073		
	Std Dev	0.1039		0.0012		0.0023			1.2166	0.0133	0.0167		
	%RSD	3.7%		2.5%		3.2%			2.7%	11.2%	8.0%		
G30		72.2	<d	0.1	<d	5.98	<d	<d	9.72	<d	<d	0.08	0.14
30A		73.4	<d	0.12	<d	6.14	<d	<d	13.1	<d	<d	0.050	0.13
30B		65.2	<d	0.11	<d	6	<d	<d	16.2	<d	<d	0.08	0.12
	Average	70.2667		0.1113		6.0400			13.0067			0.0830	0.1293
	Std Dev	4.4287		0.0081		0.0872			3.2410			0.0014	0.0114
	%RSD	6.3%		7.3%		1.4%			24.9%			1.7%	8.8%
G80		<d	<d	<d	<d	0	<d	<d	0.13	0.45	<d	<d	<d
80A		<d	<d	<d	<d	0.004	<d	<d	0.132	0.477	<d	<d	<d
80B		<d	<d	<d	<d	0.004	<d	<d	0.139	0.499	<d	<d	<d
	Average					0.0042			0.1323	0.4767			
	Std Dev					0.0002			0.0063	0.0227			
	%RSD					4.8%			4.8%	4.8%			

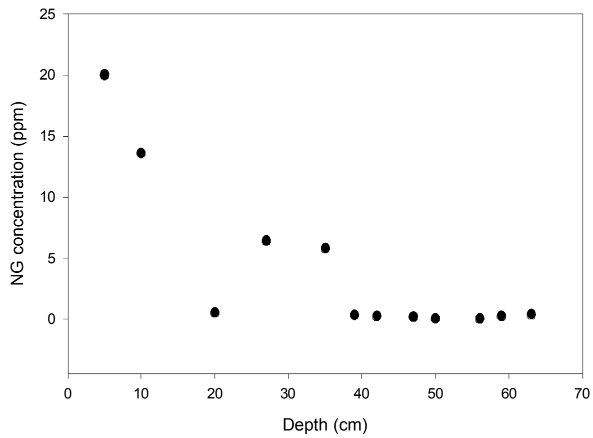
G90		<d	<d	<d	<d	<d	<d	<d	0.06	0.01	<d	<d	<d
90A		<d	<d	<d	<d	<d	<d	<d	0.13	0.01	<d	<d	<d
90B		<d	<d	<d	<d	<d	<d	<d	0.11	0.06	<d	<d	<d
	Average								0.1020	0.0273			
	Std Dev								0.0354	0.0301			
	%RSD								34.7%	110.1%			
G100		<d	<d	<d	<d	<d	<d	<d	0.120	<d	<d	<d	<d
100A		<d	<d	<d	<d	<d	<d	<d	0	<d	<d	<d	<d
100B		<d	<d	<d	<d	<d	<d	<d	0.01	<d	<d	<d	<d
	Average								0.0447				
	Std Dev								0.0653				
	%RSD								146.2%				
G70		<d	<d	0.05	<d	0.01	<d	<d	0.01	<d	<d	<d	<d
70A		<d	<d	0.02	<d	<d	<d	<d	0.02	<d	<d	<d	<d
70B		<d	<d	<d	<d	0	<d	<d	0.02	<d	<d	<d	<d
	Average			0.0350					0.0187				
	Std Dev			0.0184					0.0042				
	%RSD			52.5%					22.3%				
	Overall %RSD	3.2%		4.29%		11.78%			28.34%	35.1%		4.84%	6.08%

* Standard deviation
** Pecent relative standand deviation

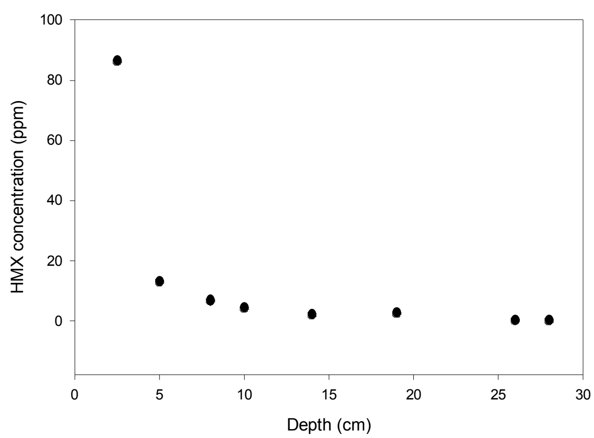
APPENDIX 4

Concentration of NG, HMX and Cu with depth, Wellington Anti-tank range-target impact area

NG concentration in profiling



HMX concentration in profiling



Cu concentration in profiling

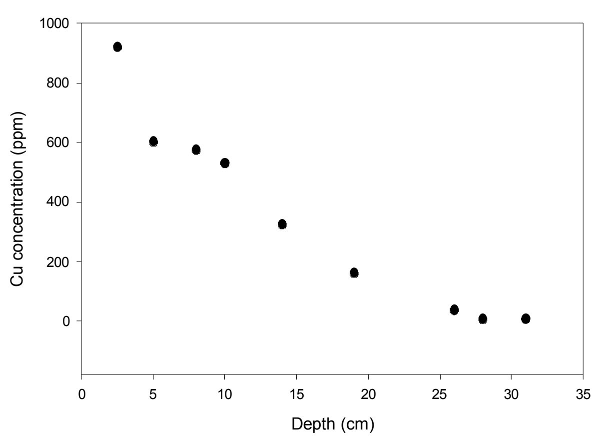


Table 1. Concenration of explosives in Background samples
Analysis by RP-HPLC and GC-ECD (shaded)

		Soil concentration, mg/Kg										
Sample #	Location	HMX	TNB	RDX	DNB	TNT	Tetryl	DNA	NG	2,4-DNT	2,6-DNT	2ADNT
	Background samples											
G103	Wellington AT Range Background In Woods	<d	<d	<d	<d	<d	<d	<d	3.54	<d	<d	<d
G104	S-BG-00800-77309	<d	<d	<d	<d	<d	<d	<d	3.66	<d	<d	<d
G105	S-BG-01080-70413	<d	<d	<d	<d	<d	<d	<d	<d	<d	<d	<d
G106	S-BG-03678-79720	<d	<d	<d	<d	<d	<d	<d	<d	<d	<d	<d
G107	S-BG-03737-65708	<d	<d	<d	<d	<d	<d	<d	<d	<d	<d	<d
G108	S-BG-07012-57921	<d	<d	<d	<d	<d	<d	<d	<d	<d	<d	<d
G109	S-BG-08340-79797	<d	<d	0	<d	<d	<d	<d	<d	0.02	<d	<d
G110	S-BG-12879-78123	<d	<d	<d	<d	<d	<d	<d	0.01	<d	<d	<d
110A	Lab Replicate Rep 1	<d	<d	<d	<d	<d	<d	<d	0.01	<d	<d	<d
110B	Lab Replicate Rep 2	<d	<d	<d	<d	<d	<d	<d	0.02	<d	<d	<d
G111	S-BG-14051-65600	<d	<d	<d	<d	<d	<d	<d	<d	<d	<d	<d
G112	S-BG-15962-74801 REP 1	<d	<d	<d	<d	<d	<d	<d	<d	0.01	<d	<d
G113	S-BG-15962-74801 REP 2	<d	<d	<d	<d	<d	<d	<d	<d	<d	<d	<d
G114	S-BG-17385-70972	<d	<d	<d	<d	<d	<d	<d	<d	<d	<d	<d
G115	S-BG-18306-72076 REP 1	<d	<d	<d	<d	<d	<d	<d	<d	<d	<d	<d
G116	S-BG-18306-72076 REP 2	<d	<d	<d	<d	<d	<d	<d	0.01	0.02	<d	<d
G117	S-BG-97286-74154	<d	<d	<d	<d	<d	<d	<d	<d	<d	<d	<d

4ADNT
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Table 2. Concentration of explosives in samples collected around targets at the Wellington Antitank Range.
Analysis by RP-HPLC and GC-ECD(shaded)

Sample #	Location	Soil concentration, mg/Kg											
		HMX	TNB	RDX	DNB	TNT	Tetryl	DNA	NG	2,4-DNT	2,6-DNT	2ADNT	4ADNT
	Targets at Anti-tank Range (Wellington)												
G1	Tanks 1 - 4, soil rep 1	1040	<d	2.28	<d	3.74	<d	<d	70.8	<d	<d	0.66	0.6
G2	Tanks 1 - 4, soil rep 2	430	<d	0.1	<d	2.6	<d	0.06	26.6	<d	<d	0.68	0.59
G3	Tanks 1 - 4, soil rep 3	424	<d	0.16	<d	0.76	<d	<d	22.4	<d	<d	0.46	0.35
G4	Tanks 1 - 4, soil rep 4	414	<d	0.18	<d	1.37	0.12	<d	26	<d	<d	0.47	0.37
G5	Tanks 1 - 4, soil rep 5	444	<d	0.15	<d	0.7	0.07	<d	24.4	<d	<d	0.43	0.32
G6	Tanks 1 - 4, soil rep 6	536	<d	0.2	<d	2.44	<d	<d	64.8	<d	<d	0.46	0.44
G7	Tanks 1 - 4, soil rep 7	270	<d	0.16	<d	0.43	<d	<d	15.9	<d	<d	0.31	0.25
G8	Tanks 1 - 4, soil rep 8	354	<d	<d	<d	1.03	0.11	0.04	19.7	<d	<d	0.3	0.25
G9	Tank 1, Organic rep 1	52.2	<d	0.05	<d	0.08	<d	<d	2.7	<d	<d	0.32	0.23
G10	Tank 1, Organic rep 2	60.6	<d	0.07	<d	0.14	0.3	0.12	6.74	<d	<d	0.37	0.29
10A	Lab Replicate rep 1	61.4	<d	0.07	<d	0.26	0.32	0.12	4.16	0.06	<d	0.46	0.31
10B	Lab Replicate rep 2	60.6	<d	0.06	<d	0.12	0.36	0.13	6.48	<d	<d	0.41	0.35
G11	Tanks 2 to 3, Organic rep 1	238	<d	0.12	<d	2.22	<d	<d	35.4	<d	<d	0.87	0.65
G12	Tanks 2 to 3, Organic rep 2	554	<d	<d	<d	8.44	<d	<d	56.8	<d	<d	1.26	0.86
G20	Tanks 2 to 3, Organic rep 3	322	0.04	0.25	<d	10.8	<d	<d	35.2	0.05	<d	1.45	1.09
20A	Lab Replicate rep 1	328	0.04	0.26	<d	12.2	<d	<d	23	0.05	<d	1.40	1.07
20 B	Lab Replicate rep 2	314	0.04	0.26	<d	11.1	<d	<d	24	0.04	<d	1.42	1.08
G13	Tank 6 Strafed Area rep 1	94.2	<d	<d	<d	0.64	<d	<d	58.6	<d	<d	0.32	0.3
G14	Tank 6 Strafed Area rep 2	126	<d	0.08	<d	0.8	<d	<d	64.2	<d	<d	0.35	0.34
G15	Strafed Area rep 1	28.8	<d	<d	<d	0.16	<d	<d	0.8	<d	<d	0.12	0.09
G16	Strafed Area rep 2	37.4	<d	<d	<d	0.04	<d	<d	4.82	<d	<d	0.15	0.08
G17	Strafed Area rep 3	17.1	<d	<d	<d	<d	0.09	<d	0.72	<d	<d	0.06	0.04
G18	Road Only rep 1	318	<d	0.08	<d	3.18	<d	<d	17.1	<d	<d	0.34	0.21
G19	Road Only rep 2	386	<d	0.12	<d	0.43	<d	<d	6.74	<d	<d	0.33	0.22
	Profile sample, Tank #2												
G128	0 To 2.5 cm	86.3	<d	<d	<d	0.12	<d	<d	2.79	<d	<d	0.52	0.73
G129	2.5 to 5 cm	13	<d	<d	<d	<d	<d	<d	1.08	<d	<d	0.310	0.47
G130	5 to 8 cm	6.68	<d	<d	<d	0.06	<d	<d	0.2	<d	<d	0.33	0.79
G131	8 to 10 cm	4.24	<d	<d	<d	0.060	<d	<d	0.140	<d	<d	0.32	0.42
G132	10 to 14 cm	2.04	<d	<d	<d	0.05	<d	<d	<d	<d	<d	0.33	0.42
G133	14 to 19 cm	2.52	<d	<d	<d	0.08	<d	<d	<d	<d	<d	0.36	0.400
G134	19 to 26 cm	0.16	<d	<d	<d	<d	<d	<d	<d	<d	<d	<d	<d
G135	26 to 28 cm	0.07	<d	<d	<d	<d	<d	<d	<d	<d	<d	<d	<d
G136	31 to 24 cm	<d	<d	<d	<d	<d	<d	<d	<d	<d	<d	<d	<d
	Demo Crater												
G171	bottom and wall of crater	189	<d	<d	<d	0.51	<d	<d	51.1	<d	<d	1.26	0.800

Table 3. Concentration of explosives in sediment and water samples collected in pools in front of targets at Wellington Antitank Range.
Analysis by RP-HPLC and GC-ECD(shaded)

		Sediment concentration, mg/Kg											
Sample #	Location	HMX	TNB	RDX	DNB	TNT	Tetryl	DNA	NG	2,4-DNT	2,6-DNT	2ADNT	4ADNT
G137	Tank #1 North side, out from tank 2m	34.2	<d	<d	<d	1.16	<d	<d	67.4	<d	<d	<d	<d
G138	Tank #1 South side, out from tank 2m	9.04	<d	<d	<d	0.749	<d	<d	32.7	<d	<d	<d	<d
G139	Tank #2 South side, out from tank 2m	64.5	<d	<d	<d	0.158	<d	<d	17.8	<d	<d	0.076	0.096
G140	Tank #2 North Side, out from tank 2m	27.5	<d	<d	<d	0.331	<d	<d	66.9	<d	<d	<d	<d
G141	Tank #3 North side, out from tank 2m	640	<d	<d	<d	2.78	<d	<d	105.2	<d	<d	<d	<d
G142	Tank #3 South side, out from tank 2m	234	<d	0.080	<d	1.36	<d	<d	47.6	<d	<d	0.106	0.128
G143	Tank #3 out from tank 9m	21.1	<d	<d	<d	0.100	<d	<d	7.96	<d	<d	<d	<d
G144	Tank #3 out from tank 12m	77.7	<d	<d	<d	0.509	<d	<d	18.7	<d	<d	0.104	0.120

		Water concentration, mg/L											
Sample #	Location	HMX	TNB	RDX	DNB	TNT	Tetryl	DNA	NG	2,4-DNT	2,6-DNT	2-ADNT	4-ADNT
G171	4m in front of tank 1	0.02	<d	<d	<d	<d	<d	<d	0	<d	<d	<d	<d
G172	10m in front of tank 2	0.02	<d	<d	<d	<d	<d	<d	0.03	<d	<d	<d	<d
G173	3m in front of tank 2	0.57	0	0	<d	0	<d	<d	1.83	<d	<d	0	0.01
G174	12m in front of tank 3	0.06	<d	<d	<d	<d	<d	<d	0.04	<d	<d	<d	<d
G175	2m in front of tank 4	0.07	<d	<d	<d	<d	<d	<d	0.07	<d	<d	<d	<d
G176	in cater 15m out in front of tank 4	0.41	<d	0	<d	<d	<d	<d	0.1	<d	<d	<d	<d

Table 4. Concentration of explosives in firing point samples at Wellington Antitank Range.

Sample #	Location	Soil concentration, mg/Kg											
		HMX	TNB	RDX	DNB	TNT	Tetryl	DNA	NG	2,4-DNT	2,6-DNT	2ADNT	4ADNT
	Behind Firing point												
G31	1m^2 Position 1	<d	<d	<d	<d	<d	<d	<d	27.6	<d	<d	<d	<d
G32	1m^2 Position 2	<d	<d	<d	<d	<d	<d	<d	612	<d	<d	<d	<d
G33	1m^2 Position 3	<d	<d	<d	<d	<d	<d	<d	594	<d	<d	<d	<d
G34	1m-2m Rep 1	<d	<d	<d	<d	<d	<d	<d	4160	<d	7	<d	<d
G35	1m-2m Rep 2	<d	<d	<d	<d	<d	<d	<d	6560	<d	10.6	<d	<d
G36	2m-5m	<d	<d	<d	<d	<d	<d	<d	4500	<d	6	<d	<d
G37	5m-10m	<d	<d	<d	<d	<d	<d	<d	3400	<d	4	<d	<d
G38	10m-20m	<d	<d	<d	<d	<d	<d	<d	2320	<d	<d	<d	<d
G39	20m-30m Rep 1	<d	<d	<d	<d	<d	<d	<d	370	<d	<d	<d	<d
G40	20m-30m Rep 2	<d	<d	<d	<d	<d	<d	<d	380	<d	<d	<d	<d
40A	Lab Replicate rep 1	<d	<d	<d	<d	<d	<d	<d	406	<d	<d	<d	<d
40B	Lab Replicate rep 2	<d	<d	<d	<d	<d	<d	<d	394	<d	<d	<d	<d
G41	30m-40m	<d	<d	<d	<d	<d	<d	<d	83.6	<d	<d	<d	<d
G42	40m-50m	<d	<d	<d	<d	<d	<d	<d	31.4	<d	<d	<d	<d
G43	0m-20m Rep 1	11.2	<d	<d	<d	<d	<d	<d	662	<d	<d	<d	<d
G44	0m-20m Rep 2	<d	<d	<d	<d	<d	<d	<d	3740	<d	5.4	<d	<d
G45	20m-50m Rep 1	<d	<d	<d	<d	<d	<d	<d	144	<d	<d	<d	<d
G46	20m-50m Rep 2	<d	<d	<d	<d	<d	<d	<d	95.8	<d	<d	<d	<d
G47	South Buffer Rep 1	<d	<d	<d	<d	<d	<d	<d	17100	<d	<d	<d	<d
G48	South Buffer Rep 2	<d	<d	<d	<d	<d	<d	<d	1880	<d	<d	<d	<d
G49	North Buffer 0-2.5 cm	<d	<d	<d	<d	<d	<d	<d	836	<d	<d	<d	<d
G50	North Buffer 2.5-5 cm	<d	<d	<d	<d	<d	<d	<d	494	<d	<d	<d	<d
50A	Lab Replicate rep 1	<d	<d	<d	<d	<d	<d	<d	494	<d	<d	<d	<d
50B	Lab Replicate rep 2	<d	<d	<d	<d	<d	<d	<d	478	<d	<d	<d	<d
G51	20m-50m "Road area"	<d	<d	<d	<d	<d	<d	<d	596	<d	<d	<d	<d
G52	20m-50m "Veg area"	<d	<d	<d	<d	<d	<d	<d	240	<d	<d	<d	<d
	Front of Firing Point												
G53	0m-10m	0.42	<d	<d	<d	<d	<d	<d	161	<d	<d	<d	<d
G54	10m-20m Rep 1	<d	<d	<d	<d	0.05	<d	<d	137	<d	0.27	<d	<d
G55	10m-20m Rep 2	<d	<d	<d	<d	<d	<d	<d	180	0.33	<d	<d	<d
G56	20m-30m	<d	<d	<d	<d	0.060	<d	<d	87	0.11	0.170	<d	<d
G57	30m-40m Rep 1	0.08	<d	<d	<d	<d	<d	<d	69.6	0.06	0.05	<d	<d
G58	30m-40m Rep 2	<d	<d	<d	<d	0.06	<d	<d	42.2	<d	<d	<d	<d
G59	40m-50m	0.14	<d	0.14	<d	<d	<d	<d	12	<d	<d	<d	<d
G60	50m-60m Rep 1	2.9	<d	0.05	<d	0.070	<d	<d	44	0.1	0.2	<d	<d
60A	Lab Replicate rep 1	2.72	<d	0.05	<d	0.07	<d	<d	46.2	0.13	0.23	<d	<d
60B	Lab Replicate rep 2	2.72	<d	0.05	<d	0.070	<d	<d	44.2	0.13	0.19	<d	<d
G61	50m-60m Rep 2	0.41	<d	<d	<d	0.04	<d	<d	24.4	<d	<d	0.03	0.1
G62	10m Line Rep 1	<d	<d	<d	<d	<d	<d	<d	260	<d	<d	<d	<d
G63	10m Line Rep 2	<d	<d	<d	<d	<d	<d	<d	318	<d	<d	<d	<d
G64	20m Line	<d	<d	<d	<d	0.04	<d	<d	77.2	<d	<d	<d	<d
G65	50m Line	<d	<d	<d	<d	0.06	<d	<d	20.4	<d	<d	<d	<d

Table 5. Concentration of explosives in profile samples collected in front and behind firing point at Wellington Antitank Range.
Analysis by RP-HPLC and GC-ECD(shaded)

		Soil concentration, mg/Kg											
Sample #	Location	HMX	TNB	RDX	DNB	TNT	Tetryl	DNA	NG	2,4-DNT	2,6-DNT	2ADNT	4ADNT
	Front, center of firing point, 10m												
G145	0 to 5 cm	<d	<d	<d	<d	<d	<d	<d	10.6	<d	<d	<d	<d
G146	5 to 7 cm	<d	<d	<d	<d	<d	<d	<d	15.3	<d	<d	<d	<d
G147	7 to 11.5 cm	<d	<d	<d	<d	<d	<d	<d	6.52	<d	<d	<d	<d
G148	11.5 to 13 cm	<d	<d	<d	<d	<d	<d	<d	0.060	<d	<d	<d	<d
G149	13 to 18 cm	<d	<d	<d	<d	<d	<d	<d	<d	<d	<d	<d	<d
G150	18 to 22 cm	<d	<d	<d	<d	<d	<d	<d	0.006	<d	<d	<d	<d
G151	22 to 27 cm	<d	<d	<d	<d	<d	<d	<d	<d	<d	<d	<d	<d
G152	27 to 31 cm	<d	<d	<d	<d	<d	<d	<d	0.020	<d	<d	<d	<d
G153	31 to 35 cm	<d	<d	<d	<d	<d	<d	<d	0.024	<d	<d	<d	<d
G154	35 to 39 cm	<d	<d	<d	<d	<d	<d	<d	0.010	<d	<d	<d	<d
G155	39 to 42 cm	<d	<d	<d	<d	<d	<d	<d	0.002	<d	<d	<d	<d
G156	42 to 47 cm	<d	<d	<d	<d	<d	<d	<d	0.004	<d	<d	<d	<d
G157	47 to 52 cm	<d	<d	<d	<d	<d	<d	<d	0.010	<d	<d	<d	<d
G158	52 to 57 cm	<d	<d	<d	<d	<d	<d	<d	0.010	<d	<d	<d	<d
	Behind, center of firing point, 10m												
G159	0 to 5 cm	<d	<d	<d	<d	<d	<d	<d	20.0	<d	<d	<d	<d
G160	5 to 10 cm	<d	<d	<d	<d	<d	<d	<d	13.6	<d	<d	<d	<d
G161	10 to 20 cm	<d	<d	<d	<d	<d	<d	<d	0.502	<d	<d	<d	<d
G162	20 to 27 cm	<d	<d	<d	<d	<d	<d	<d	6.41	<d	<d	<d	<d
G163	27 to 35 cm	<d	<d	<d	<d	<d	<d	<d	5.79	<d	<d	<d	<d
G164	35 to 39 cm	<d	<d	<d	<d	<d	<d	<d	0.322	<d	<d	<d	<d
G165	39 to 42 cm	<d	<d	<d	<d	<d	<d	<d	0.231	<d	<d	<d	<d
G166	42 to 47 cm	<d	<d	<d	<d	<d	<d	<d	0.149	<d	<d	<d	<d
G167	47 to 50 cm	<d	<d	<d	<d	<d	<d	<d	<d	<d	<d	<d	<d
G168	50 to 56 cm	<d	<d	<d	<d	<d	<d	<d	0.032	<d	<d	<d	<d
G169	56 to 59 cm	<d	<d	<d	<d	<d	<d	<d	0.222	<d	<d	<d	<d
G170	59 to 63 cm	<d	<d	<d	<d	<d	<d	<d	0.345	<d	<d	<d	<d

Table 6. Concentration of explosives in New Castle Hand Grenade Range samples .
Analysis by RP-HPLC and GC-ECD(shaded)

Sample #	Location	Soil concentration, mg/Kg											
		HMX	TNB	RDX	DNB	TNT	Tetryl	DNA	NG	2,4-DNT	2,6-DNT	2ADNT	4ADNT
	Line samples perpendicular to throw line(55m wide)												
G78	10m out	<d	<d	<d	<d	<d	<d	<d	0.42	0.21	<d	<d	<d
G79	20m out Rep 1	<d	<d	<d	<d	0	<d	<d	0.17	0.01	<d	<d	<d
G80	20m out Rep 2	<d	<d	<d	<d	0	<d	<d	0.13	0.45	<d	<d	<d
80A	Lab Replicate rep 1	<d	<d	<d	<d	0.004	<d	<d	0.132	0.477	<d	<d	<d
80B	Lab Replicate rep 2	<d	<d	<d	<d	0.004	<d	<d	0.139	0.499	<d	<d	<d
G81	30m out	<d	<d	<d	<d	<d	<d	<d	0.13	0.45	<d	<d	<d
G82	40m out Rep 1	<d	<d	<d	<d	<d	<d	<d	0.27	0.01	<d	<d	<d
G83	40m out Rep 2	<d	<d	<d	<d	<d	<d	<d	0.09	0	<d	<d	<d
G84	50m Line	<d	<d	<d	<d	<d	<d	<d	0.05	0.11	<d	<d	<d
G95	50-60m, area sample	<d	<d	<d	<d	<d	<d	<d	0.25	0.02	<d	<d	<d
	Area composites from left side of range												
G85	0-5m out	<d	<d	<d	<d	<d	<d	<d	0.04	<d	<d	<d	<d
G86	5-10m Rep 1	<d	<d	<d	<d	<d	<d	<d	0.11	0	<d	<d	<d
G87	5-10m Rep 2	<d	<d	<d	<d	<d	<d	<d	2.68	<d	<d	<d	<d
G88	10-15m	<d	<d	<d	<d	<d	<d	<d	0.26	0	<d	<d	<d
G89	15-20m	<d	<d	<d	<d	<d	<d	<d	0.12	0.03	<d	<d	<d
	Area composites from right side of range												
G90	0-5m Rep 1	<d	<d	<d	<d	<d	<d	<d	0.06	0.01	<d	<d	<d
90A	Lab Replicate rep 1	<d	<d	<d	<d	<d	<d	<d	0.13	0.01	<d	<d	<d
90B	Lab Replicate rep 2	<d	<d	<d	<d	<d	<d	<d	0.11	0.06	<d	<d	<d
G91	0-5m Rep 2	<d	<d	<d	<d	<d	<d	<d	0.360	0.02	<d	<d	<d
G92	5-10m	<d	<d	<d	<d	<d	<d	<d	0.24	0.010	<d	<d	<d
G93	10-15m	<d	<d	<d	<d	<d	<d	<d	0.74	0.02	<d	<d	<d
G94	15-20m	<d	<d	<d	<d	<d	<d	<d	0.28	0.06	<d	<d	<d

Table 7. Concentration of explosives in New Castle Rifle Grenade Range samples.
Analysis by RP-HPLC and GC-ECD(shaded)

Sample #	Location	Soil concentration, mg/Kg											
		HMX	TNB	RDX	DNB	TNT	Tetryl	DNA	NG	2,4-DNT	2,6-DNT	2ADNT	4ADNT
G96	Right target 100m - 130m	<d	<d	0.1	<d	<d	<d	<d	0.090	0.01	<d	<d	<d
G97	Center target 100m - 130m	<d	<d	<d	<d	<d	<d	<d	0.04	0.05	<d	<d	<d
G98	Left target 100m - 130m	<d	<d	0	<d	<d	<d	<d	0.14	0.010	<d	<d	<d
G99	Right target 170m - 200m	<d	<d	0.02	<d	<d	<d	<d	0.04	<d	<d	<d	<d
G100	Center 170m - 200m	<d	<d	<d	<d	<d	<d	<d	0.120	<d	<d	<d	<d
100A	Lab Replicate rep 1	<d	<d	<d	<d	<d	<d	<d	0	<d	<d	<d	<d
100B	Lab Replicate rep 2	<d	<d	<d	<d	<d	<d	<d	0.01	<d	<d	<d	<d
G101	Left target 170m - 200m rep1	0.06	<d	0.47	<d	<d	<d	<d	0.04	<d	<d	<d	<d
G102	Left target 170m - 200m rep2	0.08	<d	0.320	<d	<d	<d	<d	0.02	<d	<d	<d	<d

Table 8. Concentration of explosives from samples collected before and after the blow-in-place of 84-mm antitank rounds at Wellington demolition bunker.

		Soil concentration, mg/Kg											
Sample #	Location	HMX	TNB	RDX	DNB	TNT	Tetryl	DNA	NG	2,4-DNT	2,6-DNT	2ADNT	4ADNT
	Pre-detontation												
G21	3-m2 area, Rep1	0.51	<d	<d	<d	0.07	<d	<d	9.44	<d	<d	0.1	0.11
G22	3-m2 area, Rep2	0.26	<d	<d	<d	<d	<d	<d	20.4	<d	<d	0.1	0.110
G23	1-m dia. Circle, Rep 1	0.45	<d	<d	<d	<d	<d	<d	13.2	<d	<d	<d	<d
G24	1-m dia. Circle, Rep 2	0.31	<d	<d	<d	<d	<d	<d	18.4	<d	<d	<d	<d
	Post-detontation												
G25	3-m2 area, Rep1	161	<d	<d	<d	7.2	<d	<d	42.2	<d	<d	<d	<d
G26	3-m2 area, Rep2	119	<d	<d	<d	5.64	<d	<d	34.2	<d	<d	<d	<d
G27	1-m dia. Circle, Rep 1	92	<d	0.12	<d	6.30	<d	<d	26.4	<d	<d	0.16	0.250
G28	1-m dia. Circle, Rep 2	32	<d	<d	<d	1.76	<d	<d	107	<d	<d	<d	<d
G29	Crater #1	29.6	<d	0.07	<d	33.8	<d	<d	103	<d	<d	<d	<d
G30	Crater #2	72.2	<d	0.1	<d	5.98	<d	<d	9.72	<d	<d	0.08	0.14
30A	Lab Replicate rep 1	73.4	<d	0.120	<d	6.14	<d	<d	13.1	<d	<d	0.050	0.13
30B	Lab Replicate rep 2	65.2	<d	0.110	<d	6.00	<d	<d	16.2	<d	<d	0.08	0.120

Table 9. Concentration of explosives before and after the blow-in-place of a 500lb bomb on the Hersey impact range.
Analysis by RP-HPLC and GC-ECD(shaded)

		Soil concentration, mg/Kg											
Sample #	Location	HMX	TNB	RDX	DNB	TNT	Tetryl	DNA	NG	2,4-DNT	2,6-DNT	2ADNT	4ADNT
	Pre-detontation												
G66	Wet side, 0-3cm	<d	0.02	0.04	<d	0.02	<d	<d	<d	<d	<d	<d	<d
G67	Wet side, 3-6cm	<d	0.01	0.02	<d	0.01	<d	<d	<d	<d	<d	<d	<d
G68	Dry side, 0-3cm	<d	0.01	0.04	<d	0.01	<d	<d	<d	<d	<d	<d	<d
G69	Dry side, 3-6cm	<d	0.01	0.02	<d	0.02	<d	<d	<d	<d	<d	<d	<d
	Post-detontation												
G70	Crater Wall, Rep 1	<d	<d	0.05	<d	0.01	<d	<d	0.01	<d	<d	<d	<d
70A	Lab Replicate rep 1	<d	<d	0.02	<d	<d	<d	<d	0.02	<d	<d	<d	<d
70B	Lab Replicate rep 2	<d	<d	<d	<d	0	<d	<d	0.02	<d	<d	<d	<d
G71	Crater Wall, Rep 2	<d	<d	<d	<d	0	<d	<d	0.02	<d	<d	<d	<d
G72	Crater Wall, Rep 3	<d	<d	<d	<d	<d	<d	<d	0.02	<d	<d	<d	<d
G73	0-10m from edge, Rep 1	<d	<d	<d	<d	<d	<d	<d	0.03	<d	<d	<d	<d
G74	0-10m from edge, Rep 2	<d	<d	0.01	<d	<d	<d	<d	0.05	<d	<d	<d	<d
G75	0-10m from edge, Rep 3	<d	<d	<d	<d	<d	<d	<d	0	<d	<d	<d	<d
G76	10m to 20m from edge, rep1	<d	<d	<d	<d	<d	<d	<d	3.36	<d	<d	<d	<d
G77	10m to 20m from edge, rep2	<d	<d	0.03	<d	<d	<d		0.02	<d	<d	<d	<d

		Water concentration, mg/L											
Sample #	Location	HMX	TNB	RDX	DNB	TNT	Tetryl	DNA	NG	2,4-DNT	2,6-DNT	2-ADNT	4-ADNT
G177	surface water from pond 10m from bomb crater post-blast	<d	<d	<d	<d	<d	<d	<d	<d	<d	<d	<d	<d

Table 10. Concentration of explosives in samples collected in burn pad locations.

2003 campaign - 4 pads sampled		Concentration (mg/kg)											
sample lab ID	Sample field ID	HMX	TNB	RDX	DNB	TNT	Tetryl	DNA	NG	2,4-DNT	2,6-DNT	2ADNT	4ADNT
	S-BP1A (2002)	<d	<d	<d	<d	<d	<d	<d	<d	17	0.4	<d	<d
GAG123	S-BP1A-0713612-5077219	<d	<d	<d	<d	<d	<d	<d	<d	490.89	29.57	<d	<d
	S-BP1B (2002)	<d	<d	<d	<d	<d	<d	<d	<d	32	0.5	<d	<d
GAG124	S-BP1B-0713630-5077166	<d	<d	<d	<d	<d	<d	<d	<d	57.69	1.99	<d	<d
	S-BP-2A (2002)	<d	<d	<d	<d	<d	<d	<d	<d	2.02	<d	<d	<d
GAG127	S-BP2A-0716525-5069213	<d	<d	<d	<d	<d	<d	<d	<d	5.1	0.23	<d	<d
	S-BP-2B (2002)	<d	<d	<d	<d	0.34	<d	<d	<d	21.2	0.44	<d	<d
GAG126	S-BP2B-0716505-5069160	<d	<d	<d	<d	<d	<d	<d	<d	2.58	0.07	<d	<d
GAG121	S-BP3A-0710300-5063140	<d	<d	<d	<d	<d	<d	<d	<d	6.9	0.35	<d	<d
GAG118	S-BP4A-0702632-5068613	<d	<d	<d	<d	<d	<d	<d	0.28	1.27	0.04	<d	<d
GAG119	S-BP4B-0702655-5068559	<d	<d	<d	<d	<d	<d	<d	0.13	60.4	3.06	<d	<d
GAG120	S-BP4B-0702655-5068559	<d	<d	<d	<d	<d	<d	<d	0.53	3.99	0.06	<d	<d

Table 11 a) Metal Analysis for Background Soil Samples (S-BG)

Sample	Ag	Al	As	B	Ba	Be	Bi	Ca	Cd	Co	Cr	Cu	Fe	K	Li	Mg	Mn	Mo	Na	Ni	Pb	Rb	Sb	Se	Sn	Sr	Te	Tl	U	V	Zn
	concentration (ppm)																														
S-BG-01080-70413	na	13200	3	< 1	44	0.6	< 1	660	< 0,1	12.8	18	6	23400	780	15.9	4190	503	0.1	< 50	17	10.7	14.4	< 0,1	< 1	< 0,1	5	< 0,1	< 0,1	0.7	28	46
S-BG-01080-70413-DUP	na	12900	3	< 1	42	0.5	< 1	610	< 0,1	12.7	19	6	23100	760	15.9	4190	492	0.1	< 50	18	9.5	14.1	< 0,1	< 1	< 0,1	5	< 0,1	< 0,1	0.6	29	44
S-BG-07012-57921	na	17000	6	< 1	38	0.5	< 1	200	< 0,1	9.3	24	9	26100	640	22.9	4240	403	0.4	< 50	20	10.5	17.4	< 0,1	< 1	< 0,1	4	< 0,1	< 0,1	0.7	33	54
S-BG-13385-70972	na	12200	3	< 1	33	0.5	< 1	990	< 0,1	8.1	16	8	21200	650	13.4	3550	570	0.2	< 50	15	13.1	10.9	< 0,1	< 1	< 0,1	6	< 0,1	< 0,1	0.6	24	44
S-BG-18306-72076	na	14200	3	< 1	42	0.6	< 1	570	< 0,1	12.2	22	10	27400	820	16.5	5160	442	< 0,1	< 50	25	9.4	13.4	< 0,1	< 1	< 0,1	6	< 0,1	< 0,1	0.7	33	58
S-BG-18306-72076-DUP	na	12700	3	< 1	39	0.7	< 1	620	< 0,1	12.1	21	9	25700	720	15.6	5060	436	0.1	< 50	24	9.3	11.2	< 0,1	< 1	< 0,1	6	< 0,1	< 0,1	0.7	31	55
S-BG-14051-65200	na	10700	4	< 1	38	0.5	< 1	560	< 0,1	8.1	13	7	18800	590	12.9	3010	552	0.1	< 50	13	7.4	9.6	< 0,1	< 1	< 0,1	6	< 0,1	< 0,1	0.6	22	37
S-BG-15962-74801	na	13700	2	< 1	42	0.4	< 1	660	< 0,1	7.4	18	7	24700	750	14.3	3490	290	0.1	< 50	16	11.3	14.9	< 0,1	< 1	< 0,1	5	< 0,1	< 0,1	0.6	30	42
S-BG-15962-74801-DUP	na	13200	3	< 1	40	0.4	< 1	630	< 0,1	6.6	16	6	22900	730	14	3060	274	0.2	< 50	13	11.5	15.5	< 0,1	< 1	< 0,1	5	< 0,1	< 0,1	0.5	30	41
S-BG-12879-78123	na	33000	6	< 1	35	0.8	< 1	480	< 0,1	9	30	8	36400	510	29.1	3350	318	0.3	< 50	17	10.6	12.5	< 0,1	< 1	0.4	4	< 0,1	< 0,1	0.9	41	45
S-BG-08340-79797	na	14400	3	< 1	45	0.5	< 1	750	< 0,1	10.1	20	7	23200	890	17.4	4130	536	0.2	< 50	19	12.1	16.1	< 0,1	< 1	< 0,1	6	< 0,1	< 0,1	0.7	27	54
S-BG-08340-79797-DUP	na	14600	3	< 1	48	0.6	< 1	880	< 0,1	10.6	20	8	22800	910	17.7	4440	569	0.2	< 50	19	11.8	16.4	< 0,1	< 1	< 0,1	6	< 0,1	< 0,1	0.6	27	56
S-BG-03678-79720	na	14100	3	< 1	31	0.4	< 1	600	< 0,1	10	19	6	23100	820	16.9	4540	300	0.1	< 50	20	8.3	14.7	< 0,1	< 1	< 0,1	6	< 0,1	< 0,1	0.6	24	46
S-BG-03737-65708	na	14400	9	< 1	33	0.6	< 1	1550	< 0,1	9.2	18	11	24400	850	21	5180	426	0.3	50	17	8.6	11.7	< 0,1	< 1	< 0,1	7	< 0,1	< 0,1	1.4	28	51
S-BG-97286-74154	na	13000	3	< 1	34	0.4	< 1	2580	< 0,1	9.1	19	7	21700	780	15.6	4600	326	0.1	< 50	18	9	20.8	< 0,1	< 1	< 0,1	7	< 0,1	< 0,1	0.7	28	47
S-BG-MCALPINE-2 SACS	na	14800	6	< 1	80	0.9	< 1	760	< 0,1	12.4	21	13	29200	1030	23	5590	503	0.2	< 50	24	10.1	12.4	< 0,1	< 1	0.4	7	< 0,1	< 0,1	0.8	27	52
S-BG-HARTS	na	16600	3	< 1	86	0.8	< 1	810	< 0,1	7	22	9	20900	570	19	3500	379	0.4	< 50	18	19.5	11.6	< 0,1	< 1	< 0,1	8	< 0,1	< 0,1	0.7	30	50
S-BG-00800-77309	na	13700	3	< 1	33	0.3	< 1	650	< 0,1	5.7	14	5	16100	470	12.2	2140	202	0.2	< 50	11	12.7	11.8	< 0,1	< 1	< 0,1	5	< 0,1	< 0,1	0.5	23	38
S-BG-07012 57921	<0,1	15400	5	<1	31	0.4	9	450	<0,1	6.7	22	6	27400	950	19	3100	278	0.3	<50	16	9.5	27.1	0.2	<1	<0,1	3	<0,1	0.1	0.5	39	31
S-BG-07012 57921 Dup.	<0,1	16500	5	<1	33	0.4	3	470	<0,1	7	24	6	29400	1040	20.9	3520	272	0.3	<50	18	10.1	30	0.2	<1	<0,1	4	<0,1	0.1	0.5	42	33
S-BG-03737 65708	<0,1	19300	5	<1	43	0.6	1	550	<0,1	10.6	23	12	27200	1440	23.2	4350	506	0.3	<50	22	8.7	19	<0,1	<1	<0,1	5	<0,1	<0,1	0.6	28	54
S-BG-18306 72076 Dup.	<0,1	16300	3	<1	56	0.8	<1	860	<0,1	14.4	24	12	31200	1080	19	5670	531	0.1	<50	28	8.9	14.2	<0,1	<1	<0,1	8	<0,1	<0,1	0.8	37	58
S-BG-00800 77309	0.1	15500	3	<1	21	0.3	<1	750	<0,1	4.9	17	4	30700	510	12.8	2370	156	0.2	<50	10	8.5	15.9	<0,1	<1	<0,1	5	<0,1	0.1	0.5	44	32
S-BG-08340 79797	<0,1	14000	3	<1	52	0.6	<1	1430	0.1	10.2	17	7	25500	980	16	4700	1030	0.2	<50	16	8.9	15.4	<0,1	<1	<0,1	7	<0,1	<0,1	0.6	28	43
S-BG-17385 70970	<0,1	13500	4	<1	40	0.5	<1	1340	0.1	6.8	16	7	22100	560	14.3	2470	363	0.3	<50	14	8.1	13.5	<0,1	<1	<0,1	6	<0,1	<0,1	0.5	30	43
S-BG-03678 79720	<0,1	16900	2	<1	35	0.5	<1	740	<0,1	9.2	20	4	23200	820	22.1	3750	323	0.2	<50	17	6.8	21.1	<0,1	<1	0.2	6	<0,1	<0,1	0.5	29	48
S-BG-97286 74154	<0,1	12200	4	<1	60	0.9	<1	4730	<0,1	14.4	24	10	28300	1250	21	5620	599	0.3	<50	26	9.2	17	0.1	<1	0.6	14	<0,1	<0,1	0.8	42	32
S-BG-14051 65200	<0,1	9860	4	<1	34	0.5	<1	820	<0,1	7.8	12	7	17800	680	13.2	2730	487	0.2	<50	12	6.1	9.4	<0,1	<1	<0,1	6	<0,1	<0,1	0.5	22	36
S-BG-15962 74801 Dup.	<0,1	29500	5	<1	59	0.8	<1	490	<0,1	12.4	32	7	42300	1210	30.4	4400	417	0.3	<50	24	12.4	36.8	<0,1	<1	0.2	5	<0,1	0.2	0.7	59	56
S-BG-12879 78123	<0,1	10900	2	<1	23	0.5	<1	1160	<0,1	8.1	15	6	19800	740	14.7	3140	408	0.2	<50	16	5.6	7.7	<0,1	<1	<0,1	5	<0,1	<0,1	0.5	25	32
S-BG-12879 78123 Dup.	<0,1	11500	3	<1	20	0.5	<1	1330	<0,1	7.8	15	5	19300	700	14.3	3380	318	0.2	<50	16	5.1	7.2	<0,1	<1	<0,1	5	<0,1	<0,1	0.5	25	31
S-BG-18306 72076	<0,1	15800	3	<1	56	0.8	<1	810	<0,1	14.9	26	12	31800	1120	19.9	5900	504	0.1	<50	30	8.2	14.9	<0,1	<1	<0,1	8	<0,1	<0,1	0.8	39	61
S-BG-01080 70413	<0,1	15000	3	<1	40	0.6	<1	700	<0,1	9.3	19	4	22800	1110	17.6	3650	435	0.2	<50	17	8	21.7	<0,1	<1	0.1	7	<0,1	0.1	0.7	34	40
S-BG-15962 74801	<0,1	32900	6	<1	60	0.9	<1	470	<0,1	13.4	34	8	44200	1200	32.4	4660	429	0.4	<50	27	12.3	36.4	<0,1	<1	0.3	5	<0,1	0.2	0.7	58	63
Mean Value for BG	0.1	15690	4	1.0	43	0.58	1.200	931	0.100	9.71	20	8	25709	843	18	4024	429	0.217	50	19	10	16	0.100	1.00	0.150	6	0.100	0.150	0.656	32	46
Standard Deviation	0.00	5399	1	0.5	14	0.17	2.000	786	0.050	2.63	5	2	6123	234	5	985	152	0.087	25	5	3	7	0.050	0.50	0.180	2	0.050	0.150	0.170	9	9

	Ag	Al	As	B	Ba	Be	Bi	Ca	Cd	Co	Cr	Cu	Fe	K	Li	Mg	Mn	Mo	Na	Ni	Pb	Rb	Sb	Se	Sn	Sr	Te	Tl	U	V	Zn
MBG	0.2	26500	6.7	2.0	71	1.0	5.0	2500	0.2	15	30	12	38000	1311	28	6000	740	0.4	100	30	16	30	0.2	2.0	0.5	10	0.2	0.3	1.0	50	64
CCME ISQG (ppm)	40	N/A	12	N/A	2000	8	N/A	N/A	22	300	87	91	N/A	N/A	N/A	N/A	N/A	40	N/A	50	600	N/A	40	3.9	300	N/A	N/A	1	N/A	130	360

Legend:

BLUE: Exceeds MBG — 2002 results

RED: Exceeds ISQG — 2003 results

Table 11 b) Metal Analysis for Soils Samples Wellington Antitank Range, phase II

SOIL

Sample	Ag	Al	As	B	Ba	Be	Bi	Ca	Cd	Co	Cr	Cu	Fe	K	Li	Mg	Mn	Mo	Na	Ni	Pb	Rb	Sb	Se	Sn	Sr	Te	Tl	U	V	Zn
	Concentration (ppm)																														
S-WAT-T1	**5.3**	18200	**7**	1	**178**	0.7	**63**	1670	**10.7**	7.7	**141**	**3230**	**41000**	420	16.6	2390	480	**35.5**	< 50	**135**	**505**	8.7	**2.2**	< 1	**20.6**	**11**	< 0,1	0.1	0.6	20	**490**
S-WAT-T2	**9.2**	21000	6	**4**	**214**	0.7	**89**	**23000**	**3.5**	7.2	**75**	**3360**	25700	1100	13.6	4170	491	**15.7**	50	**54**	**276**	11.3	**0.7**	< 1	**10.3**	**42**	< 0,1	0.1	**1.4**	24	**588**
S-WAT-T2-DUP	**6.3**	19800	5	**4**	**159**	0.8	**55**	**22700**	**2.5**	7	**63**	**2300**	23100	1140	14.9	4080	472	**8.1**	100	**42**	**155**	10.8	**0.5**	< 1	**9.3**	**39**	< 0,1	< 0,1	**1.3**	25	**623**
S-WAT-T2-DEPTH 5-10	**8**	20300	6	**10**	**185**	0.7	**87**	**45500**	**2.5**	6.3	**82**	**4550**	22900	**1550**	16.1	4120	415	**20.1**	**130**	**49**	**108**	13.8	**0.3**	< 1	**11.4**	**68**	< 0,1	< 0,1	**1.8**	21	**572**
S-WAT-T3	**4.9**	12500	5	< 1	**117**	0.4	**30**	650	**4.9**	6.1	**63**	**2820**	25000	450	8.4	2050	324	**15.7**	< 50	**84**	**271**	5.8	**1.5**	< 1	**11.7**	6	< 0,1	< 0,1	0.5	16	**356**
S-WAT-T3-DUP	**5.2**	13600	5	2	**158**	0.4	**33**	600	**6.4**	6.3	**77**	**4020**	27200	450	8.5	2200	348	**18.3**	< 50	**93**	**254**	6	**1.4**	< 1	**16.2**	7	< 0,1	< 0,1	0.4	17	**365**
S-WAT-T4	**2.6**	17400	5	**5**	**173**	0.6	**87**	**13500**	**2.5**	7.4	**68**	**2300**	23600	890	12.1	3800	472	**10**	< 50	**78**	**132**	8.8	**1.6**	< 1	**8**	**27**	< 0,1	< 0,1	1	21	**456**
S-WAT-T5	**1.5**	11000	2	< 1	44	0.2	**12**	640	**1.5**	4.7	**38**	**879**	16600	320	8.3	1880	408	**5.6**	< 50	**42**	**266**	6.5	**0.9**	< 1	**4.2**	5	< 0,1	< 0,1	0.4	16	**218**
S-WAT-FP-FRONT	< 0,1	11500	4	< 1	34	0.4	**18**	820	< 0,1	7	15	**16**	18300	650	12.8	3300	310	0.2	< 50	22	8.5	11.1	< 0,1	< 1	< 0,1	6	< 0,1	< 0,1	0.6	24	55
S-WAT-OD PIT	0.1	16600	3	1	33	0.3	5	430	< 0,1	8.3	18	**18**	20800	530	15.6	3430	213	0.4	< 50	17	9.1	16.1	< 0,1	< 1	< 0,1	5	< 0,1	0.1	0.6	28	46
S-WAT-FP-CORE 10M (2-5)	< 0,1	14500	3	1	36	0.3	< 1	510	< 0,1	7.3	17	6	20400	540	14.6	3150	242	0.2	< 50	15	10.7	14.9	< 0,1	< 1	< 0,1	5	< 0,1	0.1	0.6	26	**72**
S-WAT-FP-CORE 20M (2-5)	< 0,1	16000	4	1	36	0.4	2	290	< 0,1	9.7	20	6	20200	590	16.2	3890	270	0.1	< 50	19	14.5	15.2	< 0,1	< 1	< 0,1	**15**	< 0,1	0.1	0.7	28	**69**
S-WAT-SP-BACK	< 0,1	8450	5	**58**	26	0.4	2	**2600**	**0.7**	6.8	25	**14**	19000	630	13.1	3830	281	**2.6**	< 50	**32**	**34.2**	6.7	0.1	< 1	**15.6**	**11**	< 0,1	< 0,1	0.6	19	40

MBG	0.2	26500	6.7	2.0	71	1.0	5.0	2500	0.2	15	30	12	38000	1311	28	6000	740	0.4	100	30	16	30	0.2	2.0	0.5	10	0.2	0.3	1.0	50	64
CCME ISQG (ppm)	40	N/A	12	N/A	2000	8	N/A	N/A	22	300	87	91	N/A	N/A	N/A	N/A	N/A	40	N/A	50	600	N/A	40	3.9	300	N/A	N/A	1	N/A	130	360

Legend:
BLUE: Exceeds MBG
RED: Exceeds ISQG

Table 11 c) Metal Analysis for Soil Samples, Antitank Range, phase III: target Area and EOD Bunk

Sample	Ag	Al	As	B	Ba	Be	Bi	Ca	Cd	Co	Cr	Cu	Fe	K	Li	Mg	Mn	Mo	Na	Ni	Pb	Rb	Sb	Se	Sn	Sr	Te	Tl	U	V	Zn	sample description
	Concentration (ppm)																															
GAG 001	**2.8**	13600	4	1	**99**	0.7	**24**	1500	**4.2**	7.6	**73**	**1540**	29500	700	12.8	2820	366	**13.4**	80	**63**	**171**	8.4	**1.1**	<1	**11.8**	8	<0,1	<0,1	0.5	23	**264**	Composite sample from road and pads next to tank targets, Chuck 44 incs
GAG 002	**3.9**	17700	4	2	**89**	0.7	**40**	2350	**3.2**	8	**57**	**1780**	22800	710	15	3090	373	**8.5**	50	**60**	**144**	9	**1.2**	<1	**12.5**	9	<0,1	0.1	0.6	25	**523**	Composite sample from road and pads next to tank targets, Chuck 46 incs
GAG 003	**2.8**	15300	4	1	**92**	0.7	**33**	1710	**3.3**	8.4	**62**	**1140**	25200	830	14.6	3840	418	**18**	70	**50**	**124**	9.2	**1.2**	<1	**11.5**	8	<0,1	<0,1	0.6	26	**209**	Composite sample from road and pads next to tank targets, Alan 44 incs
GAG 004	**4.1**	15500	5	2	**107**	0.6	**46**	2140	**4.9**	7.5	**46**	**1570**	24400	730	13.2	2550	343	**9.8**	50	**58**	**186**	9.8	**1.4**	<1	**13.2**	10	<0,1	0.1	0.6	25	**286**	Composite sample from road and pads next to tank targets, Alan 44 incs
GAG 005	**2.8**	12700	4	2	**126**	0.7	**35**	1440	**3**	7.6	**97**	**2260**	22600	700	12.3	2600	329	**15**	<50	**55**	**134**	8.7	**1.2**	<1	**11**	**11**	<0,1	<0,1	0.5	23	**257**	Composite sample from road and pads next to tank targets, Sonia 44 incs
GAG 006	**3.6**	14200	5	**3**	**89**	0.6	**35**	**3460**	**4.2**	7.8	**43**	**1450**	24700	780	13.6	2940	467	**12.4**	<50	**51**	**173**	9.2	**1.7**	1	**11.3**	**11**	<0,1	<0,1	0.6	24	**225**	Composite sample from road and pads next to tank targets, Sonia 44 incs
GAG 007	**3.6**	14700	4	1	**90**	0.6	**35**	1880	**5.4**	7.6	**52**	**1430**	34200	710	13.5	2620	353	**8.9**	<50	**55**	**177**	9	**1.3**	<1	**11.5**	8	<0,1	0.1	0.6	25	**301**	Composite sample from road and pads next to tank targets, Marianne 44 incs
GAG 008	**4.1**	15000	5	1	**92**	0.6	**34**	1640	**3**	7.5	**57**	**1520**	23200	800	13.3	3280	361	**11.7**	<50	**52**	**135**	9.5	**1.1**	<1	**9.6**	8	<0,1	<0,1	0.6	23	**182**	Composite sample from road and pads next to tank targets, Marianne 44 incs
GAG 009	**2.7**	13400	4	**8**	**96**	0.7	**41**	1530	**4.7**	8.2	**80**	**1080**	22700	900	16.2	1940	590	**15.9**	<50	**78**	**235**	14.5	**7.6**	<1	**11.9**	10	<0,1	0.1	0.6	24	**241**	Composite sample of surface organics near tank #1 target, Chuck 32 incs
GAG 010	**3.1**	15800	3	2	**120**	0.6	**48**	1850	**7.3**	7.6	**50**	**1200**	20300	980	16.6	2140	635	**11.5**	<50	**62**	**246**	15.6	**1.9**	<1	**12.3**	**12**	<0,1	0.1	0.6	24	**334**	Composite sample of surface organics near tank #1 target, Chuck 33incs
GAG 011	**6.8**	16100	3	2	**110**	0.5	**74**	2040	**12.2**	4.2	**40**	**2320**	17400	660	9.9	1770	324	**7.3**	<50	**42**	**206**	9.6	**1.5**	<1	**14.8**	**11**	<0,1	0.1	0.4	22	**312**	Composite sample of surface organics between tanks #2- 3 targets, Chuck 29 incs
GAG 012	**4.9**	13800	4	2	**120**	0.5	**80**	**2540**	**8.6**	5.4	**51**	**1480**	19900	680	12	1890	348	**14.9**	<50	**64**	**241**	11	**2.1**	<1	**18.8**	**12**	<0,1	0.1	0.5	26	**371**	Composite sample of surface organics between tanks #2 -3 targets, Chuck 31 incs
GAG 013	**2**	14500	4	2	61	0.5	**29**	440	**3.6**	6.3	**32**	**660**	23200	660	15.7	2340	270	**3.6**	<50	27	**194**	14.4	**1.6**	<1	**8.6**	8	<0,1	0.1	0.6	36	**257**	Composite sample from trench in front of Tank #5, Chuck 35 incs
GAG 014	**1.9**	12100	4	2	57	0.4	**16**	500	**2.9**	5.5	28	**671**	23000	670	12.9	1970	234	**2.2**	<50	23	**146**	13.8	**1.6**	<1	**7.9**	8	<0,1	0.1	0.5	30	**205**	Composite sample from trench in front of Tank #5, Marianne 30 incs
GAG 015	**1.2**	12100	3	1	42	0.3	**20**	370	**2.1**	3.1	18	**641**	15800	430	9.4	1450	117	**1**	<50	14	**76.1**	9.6	**0.6**	<1	**7.4**	6	<0,1	0.1	0.5	31	**115**	Composite sample from strafed area beyond road, Chuck 40 incs
GAG 016	**1.6**	14100	3	1	48	0.3	**23**	470	**2.8**	2.9	24	**600**	16200	430	8.6	1400	134	**1**	<50	14	**84.3**	9.2	**0.6**	<1	**7.2**	5	<0,1	0.1	0.4	30	**278**	Composite sample from strafed area beyond road, Alan 33 incs
GAG 017	**1.4**	12200	3	1	43	0.3	**23**	370	**2.3**	3.3	18	**528**	16300	450	9.6	1440	134	**1.2**	<50	14	**75.2**	9.4	**0.7**	<1	**7.8**	5	<0,1	0.1	0.4	29	**102**	Composite sample from strafed area beyond road, Marianne 40 incs
GAG 018	**2.4**	12800	4	<1	71	0.7	**25**	1760	**1.9**	8.9	**37**	**2100**	27200	810	15.7	3560	444	**5**	<50	**37**	**113**	9.1	**1.2**	<1	**10.5**	8	<0,1	<0,1	0.6	27	**264**	Composite sample from road next to tank targets, Chuck 48 incs
GAG 019	**2**	13200	5	1	**91**	0.9	**23**	1110	**2**	10.8	**36**	**693**	26200	890	17.2	3400	434	**4.4**	<50	**47**	**113**	10.9	**1**	<1	**9.7**	9	<0,1	0.1	0.6	27	**198**	Composite sample from road next to tank targets, Chuck 45 incs
GAG 020	**5.3**	21000	3	2	**140**	0.5	**77**	2120	**10**	4.8	**50**	**1800**	19100	720	11.2	1940	378	**6.1**	<50	**42**	**222**	11.4	**2.1**	<1	**17.2**	**12**	<0,1	0.1	0.4	26	**563**	Composite sample from plateau area near tank, Chuck 30 incs
GAG 021	0.2	14800	3	2	33	0.4	<1	320	**0.4**	8.5	18	**22**	22700	730	15.2	3120	276	0.2	<50	17	10.1	15.9	0.1	<1	**3.4**	5	<0,1	0.2	0.5	32	47	Before BIP 84-mm Chuck Rep 14 incs
GAG 022	0.2	16100	3	2	34	0.4	1	350	**0.7**	9.2	20	**27**	23800	670	17.6	2940	265	0.2	<50	18	16	16.4	0.1	1	**3.9**	5	<0,1	0.1	0.6	34	56	Before BIP 84-mm Chuck Rep 2 14 incs
GAG 023	0.1	14500	3	**3**	31	0.4	1	290	**0.3**	8.2	19	**31**	21300	650	15.3	2770	214	0.2	<50	18	9.2	15.2	0.1	<1	**3.8**	5	<0,1	0.1	0.4	31	47	Before BIP 84-mm Guy Rep 1 30 incs
GAG 024	0.1	15100	3	2	29	0.4	<1	280	**0.3**	8	18	**23**	21300	650	15.1	2690	231	0.2	80	17	12.7	14.6	0.1	<1	**3.4**	4	<0,1	0.1	0.5	33	45	Before BIP 84-mm Guy Rep 2 30 incs
GAG 025	0.1	14600	3	2	28	0.4	<1	340	**0.6**	7.5	17	**27**	19800	720	13.6	2740	226	0.2	**150**	15	9.4	14.4	0.1	<1	**3.9**	4	<0,1	0.1	0.4	29	46	After BIP 84-mm Chuck Rep 1 14 incs
GAG 026	0.1	15600	4	2	32	0.4	1	330	**0.6**	8.2	19	**27**	21200	770	15.2	3000	233	0.2	**120**	17	11.2	16.4	0.1	<1	**3.9**	5	<0,1	0.1	0.5	33	49	After BIP 84-mm Chuck Rep 2 14 incs
GAG 027	0.1	14900	3	2	29	0.4	<1	350	**0.3**	7.3	18	**26**	20600	620	14.7	2670	218	0.2	<50	16	9	13.8	0.1	<1	**3.3**	5	<0,1	0.1	0.5	30	46	After BIP 84-mm Guy Rep 1 30 incs
GAG 028	0.1	16600	3	**5**	33	0.4	<1	330	**0.4**	8.2	20	**26**	22100	660	16.8	2870	222	0.2	<50	18	10	15.2	0.1	<1	**3.3**	4	<0,1	0.1	0.5	34	52	After BIP 84-mm Guy Rep 2 30 incs
GAG 029	0.2	17800	4	2	36	0.5	<1	410	**0.4**	11.2	21	12	25800	900	19.1	3590	329	0.2	**150**	21	10.6	19.6	0.1	<1	**3.9**	6	<0,1	0.1	0.6	35	61	After BIP 84-mm Crater 1 Alan
GAG 030	0.2	15100	4	2	36	0.5	1	310	**1.3**	10.6	21	**58**	27200	810	16.8	3740	304	0.2	50	20	15	17	0.1	<1	**5.4**	6	<0,1	0.1	0.7	43	60	After BIP 84-mm Crater 2 Alan

	Ag	Al	As	B	Ba	Be	Bi	Ca	Cd	Co	Cr	Cu	Fe	K	Li	Mg	Mn	Mo	Na	Ni	Pb	Rb	Sb	Se	Sn	Sr	Te	Tl	U	V	Zn
MBG	0.2	26500	6.7	2.0	71	1.0	5.0	2500	0.2	15	30	12	38000	1311	28	6000	740	0.4	100	30	16	30	0.2	2.0	0.5	10	0.2	0.3	1.0	50	64
CCME ISQ(	40	N/A	12	N/A	2000	8	N/A	N/A	22	300	87	91	N/A	N/A	N/A	N/A	N/A	40	N/A	50	600	N/A	40	3.9	300	N/A	N/A	1	N/A	130	360

Legend:
BLUE: Exceeds MBG
RED: Exceeds ISQG

Table 11 d) Metal Analysis for Soil Samples, Antitank Range, phase III: Behind and in Front of Firing Positio

Sample	Ag	Al	As	B	Ba	Be	Bi	Ca	Cd	Co	Cr	Cu	Fe	K	Li	Mg	Mn	Mo	Na	Ni	Pb	Rb	Sb	Se	Sn	Sr	Te	Tl	U	V	Zn	Sample description
	Concentration (ppm)																															
GAG 031	0.1	7130	**8**	**5**	28	0.4	1	**4600**	**1.6**	6.2	13	**20**	16100	940	13.5	3960	315	**2**	**250**	17	9	8.8	**0.3**	1	**3.6**	**14**	<0,1	<0,1	0.7	17	38	Behind FP 0m-1m Rep 1
GAG 032	0.1	7540	6	**8**	35	0.5	2	**5280**	**2.8**	7.9	15	**21**	19200	960	13.1	4390	334	0.4	**220**	21	9.6	9.4	**0.4**	<1	**3.9**	**20**	<0,1	<0,1	0.8	19	46	Behind FP 0m-1m Rep 2
GAG 033	0.1	6600	6	**9**	29	0.5	2	**5170**	**2.5**	6.7	14	**18**	17100	800	11.6	3820	337	0.3	**170**	19	10.1	7.5	**0.4**	<1	**3.7**	**24**	<0,1	<0,1	0.8	19	41	Behind FP 0m-1m Rep 3
GAG 034	0.1	8170	5	**17**	32	0.4	3	2430	**3.1**	6.4	16	**21**	16800	780	11.6	2900	274	0.4	**160**	16	**16.3**	9.5	**0.4**	<1	**3.5**	9	<0,1	<0,1	0.6	20	48	Behind FP 1m-2m Rep 1
GAG 035	0.1	7500	5	**19**	27	0.4	1	**3210**	**2.8**	7.3	15	**17**	16800	700	12.5	3480	314	0.4	100	21	10.3	7.3	**0.3**	<1	**3.6**	**11**	<0,1	<0,1	0.6	16	48	Behind FP 1m-2m Rep 2
GAG 036	0.1	8860	4	**21**	27	0.5	<1	780	**0.5**	6.9	14	**17**	17100	700	14.2	3120	275	0.2	<50	16	9.4	9.2	0.1	<1	**3.3**	10	<0,1	0.1	0.6	18	46	Behind FP 2m-5m
GAG 037	0.1	10100	3	**6**	22	0.5	<1	540	0.1	8	16	12	23200	740	15.8	3150	298	**0.6**	<50	19	7.8	8.2	**0.6**	<1	**3.8**	**14**	<0,1	<0,1	0.5	22	44	Behind FP 5m-10m
GAG 038	0.1	9640	3	**6**	28	0.5	1	650	0.20	7.1	13	9	19800	660	11.8	2570	335	0.3	<50	16	9.4	8.3	**0.3**	<1	**2.6**	5	<0,1	<0,1	0.5	22	42	Behind FP 10m-20m
GAG 039	0.1	9960	3	2	43	0.5	<1	1410	**0.3**	9.1	14	**13**	20600	820	12.7	3070	502	0.4	50	18	9.1	7.5	0.1	<1	**2.6**	7	<0,1	<0,1	0.5	20	50	Behind FP 20m-30m Rep 1
GAG 040	0.1	10800	4	**3**	47	0.6	<1	980	0.20	9.1	17	**14**	22500	900	14	2770	465	**0.8**	<50	19	12.2	9.7	0.1	<1	**3.4**	8	<0,1	0.1	0.6	23	54	Behind FP 20m-30m Rep 2
GAG 041	0.1	10600	3	1	35	0.5	<1	470	0.20	8	19	9	20400	660	13.5	2830	354	0.3	70	17	8.4	9.1	0.1	<1	**3.1**	5	<0,1	0.1	0.5	25	44	Behind FP 30m-40m
GAG 042	0.1	10900	3	1	44	0.5	<1	410	<0,1	8	16	10	24100	640	13.5	2500	319	0.2	60	17	8.8	10.1	0.1	<1	**3.7**	5	<0,1	0.1	0.5	26	46	Behind FP 40m-50m
GAG 043	**2.9**	12100	5	**3**	**84**	0.8	**39**	1960	**3.6**	6.9	**32**	**838**	30600	800	13	2710	325	**1.2**	**120**	27	**114**	9.1	**1.2**	<1	**11.5**	9	<0,1	<0,1	0.7	27	**166**	Behind FP 0m-20m Rep 1 37 incs
GAG 044	0.1	8230	3	**8**	29	0.4	**7**	1170	**0.5**	6.9	13	12	19900	660	11.2	2430	334	0.4	90	15	9.4	8	0.2	<1	**3.4**	**12**	<0,1	<0,1	0.5	25	45	Behind FP 0m-20m Rep 2 35 incs
GAG 045	0.1	11200	4	2	40	0.5	1	650	0.20	8.5	17	10	2300	760	14.4	2810	349	0.2	**110**	18	9.6	11.1	0.1	1	**3.1**	6	<0,1	0.1	0.5	28	48	Behind FP 20m-50m Rep 1
GAG 046	0.1	10700	3	2	40	0.5	<1	600	0.1	8.5	16	10	22200	720	14	2760	326	0.3	<50	17	8.8	10.8	<0,1	<1	**3.2**	6	<0,1	0.1	0.5	26	47	Behind FP 20m-50m Rep 2
GAG 047	0.1	10600	3	**4**	38	0.5	<1	670	0.1	7.7	16	10	21700	760	12.4	2670	325	0.3	100	16	10.4	10.1	0.1	<1	**3.5**	5	<0,1	0.1	0.6	28	42	Behind FP South Buffer Rep 1
GAG 048	0.1	11200	4	**4**	38	0.5	<1	450	0.1	8.2	16	12	21400	730	13.3	2520	318	0.3	60	16	10.4	10.7	0.1	<1	**3.3**	5	<0,1	0.1	0.5	27	47	Behind FP South Buffer Rep 2
GAG 049	0.1	12000	3	**3**	41	0.3	<1	680	0.1	6.8	16	8	19800	660	12.8	2090	314	0.3	60	14	10.8	15	0.1	<1	**3.3**	6	<0,1	0.1	0.4	29	50	Behind FP North Buffer Biomass
GAG 050	0.1	13200	6	**3**	35	0.3	<1	470	<0,1	6.5	16	6	21000	550	13.6	2140	258	0.2	90	13	9.6	14.3	0.1	<1	**3.7**	5	<0,1	0.1	0.5	31	45	Behind FP North Buffer "Soil"
GAG 051	0.1	9150	6	2	44	0.6	<1	740	<0,1	10.1	15	**13**	22900	840	13.7	2920	420	0.2	60	19	8.3	8.2	0.1	<1	**3.7**	6	<0,1	<0,1	0.6	22	49	Behind FP 20m-50m Road MEW
GAG 052	0.1	9050	3	2	48	0.5	<1	1210	0.20	8.7	14	12	19700	970	12.1	2640	446	0.3	70	18	7.8	8.7	0.1	1	**2.8**	7	<0,1	0.1	0.4	20	50	Behind FP 20m-50m Veg Chuck
GAG 053	0.1	11400	5	**6**	42	0.5	3	1580	**0.6**	7.5	21	**30**	21200	1160	18.2	3850	315	0.2	70	21	12.4	12.9	0.2	<1	**3.3**	8	<0,1	0.1	0.7	28	**69**	Front FP 0m-10m
GAG 054	0.1	13000	4	2	36	0.4	**13**	530	0.20	9.2	19	9	22100	720	15.4	2900	282	0.2	90	23	**27**	15.6	0.1	<1	**3.5**	6	<0,1	0.1	0.6	32	**86**	Front FP 10m-20m Rep 1
GAG 055	0.1	12600	3	**3**	44	0.4	**1560**	680	0.20	8.6	18	10	21000	750	13.7	2900	336	0.2	60	**96**	13.8	15.2	0.1	<1	**3.2**	7	<0,1	0.1	0.6	31	**77**	Front FP 10m-20m Rep 2
GAG 056	0.1	11700	3	**3**	53	0.4	**117**	680	**0.3**	7.1	16	**18**	20500	690	12.8	2500	322	0.2	60	19	**21**	14.2	0.2	<1	**3.2**	10	<0,1	0.1	0.5	29	**95**	Front FP 20m-30m
GAG 057	0.2	8850	3	**4**	67	0.3	**53**	1300	**0.5**	5	13	**20**	15200	620	9.2	1580	318	0.3	<50	14	**19.2**	12.8	0.2	<1	**2.8**	**14**	<0,1	0.1	0.4	22	**86**	Front FP 30m-40m Rep 1
GAG 058	0.2	7190	3	**4**	**85**	0.2	**19**	1530	**0.6**	3.8	11	**17**	13800	620	6.6	1190	397	0.3	<50	10	**24.6**	12	0.2	<1	**2.8**	**17**	<0,1	0.1	0.3	26	**68**	Front FP 30m-40m Rep 2
GAG 059	0.2	8600	4	**3**	70	0.3	5	1320	**0.4**	5.1	13	**13**	17700	560	9	1560	398	0.3	50	10	**19.3**	13.2	0.2	<1	**3**	**18**	<0,1	0.1	0.4	32	52	Front FP 40m-50m
GAG 060	0.1	4470	4	**4**	**90**	0.2	2	1420	**0.5**	2	7	12	6880	600	2.4	740	586	0.3	**150**	4	**18.6**	9	0.1	<1	**2**	**15**	<0,1	0.1	0.3	16	32	Front FP 50m-60m Rep 1
GAG 061	0.2	6550	2	**3**	**88**	0.2	2	1480	**0.5**	2.8	10	**14**	12700	620	5.7	1020	511	0.3	**190**	6	**23.7**	10.2	0.2	<1	**2.8**	**17**	<0,1	0.1	0.3	24	38	Front FP 50m-60m Rep 2

	Ag	Al	As	B	Ba	Be	Bi	Ca	Cd	Co	Cr	Cu	Fe	K	Li	Mg	Mn	Mo	Na	Ni	Pb	Rb	Sb	Se	Sn	Sr	Te	Tl	U	V	Zn
MBG	0.2	26500	6.7	2.0	71	1.0	5.0	2500	0.2	15	30	12	38000	1311	28	6000	740	0.4	100	30	16	30	0.2	2.0	0.50	10	0.2	0.3	1.0	50	64
CCME ISQG (ppm)	40	N/A	12	N/A	2000	8	N/A	N/A	22	300	87	91	N/A	N/A	N/A	N/A	N/A	40	N/A	50	600	N/A	40	3.9	300	N/A	N/A	1	N/A	130	360

Legend:
BLUE: Exceeds MBG
RED: Exceeds ISQG

Table 11 e) Metal Analysis for Soil Samples, Antitank Range, phase III: Front of FP, Depth profile in Target Area and Sedim

Sample	Ag	Al	As	B	Ba	Be	Bi	Ca	Cd	Co	Cr	Cu	Fe	K	Li	Mg	Mn	Mo	Na	Ni	Pb	Rb	Sb	Se	Sn	Sr	Te	Tl	U	V	Zn	Sample description
	Concentration (ppm)																															
GAG 062	<0,1	11600	3	2	46	0.4	4	650	**0.3**	8.1	17	10	21800	770	13.9	2710	324	0.2	100	19	12.4	14.7	0.1	<1	**3.2**	7	<0,1	0.1	0.5	32	**88**	Front 10m Line Rep 1, Composite along line like last year.
GAG 063	<0,1	12000	5	**3**	47	0.4	**7**	660	**0.3**	8.8	17	12	20100	740	13.8	2640	375	0.2	100	20	12.4	14.8	0.1	<1	**2.8**	7	<0,1	0.1	0.5	30	**102**	Front 10m Line Rep 2, Composite along line like last year.
GAG 064	<0,1	12600	3	2	40	0.4	**23**	510	0.2	8	17	11	20000	700	14.2	2570	300	0.3	80	20	13.2	15.5	0.1	<1	**3.3**	7	<0,1	0.1	0.5	31	**92**	Front AT FP 20m Line, Composite along line like last year.
GAG 065	0.1	7460	3	**3**	70	0.3	**7**	1350	**0.3**	3.9	11	11	14600	420	6.8	1270	343	0.2	<50	8	**16.6**	11.1	0.1	<1	**2.7**	**16**	<0,1	0.1	0.4	26	35	Front AT FP 50m Line, Composite along line like last year.
GAG 128	**2.1**	18500	4	2	**187**	0.4	**14**	**3370**	**2.7**	5	27	**920**	20600	610	21.8	2790	198	**2.7**	60	24	**81.8**	11	**0.5**	<1	**8.4**	**12**	<0,1	**0.4**	0.7	29	**182**	Depth Profile Near Tank Target #2 0 To 2.5 cm side wall
GAG 129	**1.2**	12900	3	2	**83**	0.3	**7**	1480	**1.8**	5.1	17	**601**	15200	510	20.4	2670	195	**1.2**	<50	18	**38.6**	8.9	0.2	<1	**5.5**	7	<0,1	**0.4**	0.5	24	**99**	Depth Profile Near Tank Target #2 2.5 to 5 cm side wall
GAG 130	**1.2**	12300	3	<1	70	0.3	5	1290	**1.6**	4.8	14	**574**	13000	500	19.1	2790	187	**0.7**	<50	16	**22.8**	8.4	0.1	<1	**5.1**	6	<0,1	0.3	0.5	22	**84**	Depth Profile Near Tank Target #2 5 to 8 cm side wall
GAG 131	**1.5**	12800	2	**4**	**83**	0.2	5	760	**1.9**	4.9	15	**529**	13200	500	20.8	2660	186	**1.2**	60	17	**21**	9	0.1	<1	**5.2**	6	<0,1	0.3	0.5	21	**84**	Depth Profile Near Tank Target #2 8 to 10 cm side wall
GAG 132	**0.6**	12400	3	**5**	71	0.3	3	530	**1.2**	5.3	14	**324**	12200	490	20.8	2750	185	0.4	70	16	14	8.5	0.1	<1	**4.1**	6	<0,1	0.3	0.5	22	**70**	Depth Profile Near Tank Target #2 10 to 14 cm side wall
GAG 133	**0.4**	13500	5	**4**	65	0.3	3	640	**0.8**	6.2	16	**160**	14800	550	25.6	2830	197	**0.5**	<50	18	11.6	9.3	0.1	<1	**4.3**	6	<0,1	0.3	0.5	26	58	Depth Profile Near Tank Target #2 14 to 19 cm side wall
GAG 134	0.1	10600	5	**4**	66	0.3	1	680	**0.5**	6.1	14	**36**	13900	480	24.6	2460	177	0.4	<50	19	7.3	7.2	0.1	<1	**4**	6	<0,1	0.3	0.5	24	43	Depth Profile Near Tank Target #2 19 to 26 cm side wall
GAG 135	<0,1	6770	6	**4**	65	0.4	<1	1450	<0,1	6.4	11	6	14800	640	11.5	2720	308	0.4	<50	13	5.6	7.2	0.1	<1	**3.9**	8	<0,1	0.3	0.7	22	30	Depth Profile Near Tank Target #2 26 to 28 cm side wall
GAG 136	<0,1	6090	4	**5**	68	0.4	<1	1810	0.1	7	11	7	14100	680	9.4	2760	**978**	0.2	**110**	15	8.2	6.4	0.1	<1	**4**	9	<0,1	0.3	0.9	21	33	Depth Profile Near Tank Target #2 31 to 24 cm core bottom of hole
GAG 137	**11.4**	23000	**24**	**8**	**295**	0.8	**131**	1250	**17.1**	12.9	**288**	**10600**	**60900**	460	17.7	1890	**805**	**78.3**	70	**326**	**25000**	8	**117**	<1	**133**	**11**	0.2	**1.6**	0.7	20	**898**	Sediment from Ponds near Tank Targets #1 Sediment North side
GAG 138	**8**	**29600**	**13**	**6**	**375**	1	**166**	960	**15.9**	11.5	**289**	**7340**	**58900**	470	19.5	1950	**633**	**79.4**	60	**248**	**1250**	10.5	**6.1**	<1	**74.2**	**13**	<0,1	**0.5**	0.7	22	**1130**	Sediment from Ponds near Tank Targets #1 Sediment South side
GAG 139	**5.7**	26300	6	**3**	**243**	0.7	**84**	**3300**	**5**	8.4	**92**	**2220**	28000	641	**39.1**	2890	478	**16**	70	**70**	**304**	15.3	**1.3**	1	**20.2**	**17**	<0,1	**0.4**	0.8	27	**622**	Sediment from Ponds near Tank Targets #2 Sediment South side
GAG 140	**8.9**	**30400**	5	**3**	**238**	0.8	**141**	**4310**	**6.5**	8.4	**88**	**2600**	32900	820	**32.7**	2860	691	**16.8**	**120**	**84**	**365**	17.4	**1.2**	<1	**23.3**	**21**	<0,1	**0.4**	0.9	28	**371**	Sediment from Ponds near Tank Targets #2 Sediment North Side
GAG 141	**8.4**	**40500**	**7**	**5**	**576**	0.5	**80**	650	**12**	8.9	**203**	**8130**	**42500**	450	7.7	1810	507	**75.6**	70	**249**	**411**	6.8	**3.9**	<1	**35.4**	**13**	<0,1	0.3	0.5	20	**1150**	Sediment from Ponds near Tank Targets #3 Sediment North side, Close 5 ft
GAG 142	**5.8**	20800	**7**	**6**	**174**	0.7	**70**	610	**10.5**	7.7	**181**	**4020**	37000	530	9.8	1960	392	**72.5**	60	**225**	**361**	7.4	**2.7**	<1	**34**	9	<0,1	0.3	0.5	23	**745**	Sediment from Ponds near Tank Targets #3 Sediment South side 5 ft
GAG 143	**5**	13300	2	**4**	**133**	0.5	**54**	850	**2.7**	5.6	**39**	**1160**	17800	610	15.3	2380	322	**6.2**	50	**42**	**171**	10.4	**0.8**	<1	**14.6**	9	<0,1	0.3	0.5	23	**230**	Sediment from Ponds near Tank Targets #3 Sediment out at 26 to 28 ft
GAG 144	**6.7**	16600	3	**4**	**163**	0.6	**73**	1270	**6.3**	7.4	**64**	**2130**	24800	630	11.4	2340	**1320**	**11.6**	60	**76**	**277**	10.1	**1.7**	<1	**22**	**11**	<0,1	0.3	0.5	24	**758**	Sediment from Ponds near Tank Targets #3 Sediment out at 11,12,13 yards

	Ag	Al	As	B	Ba	Be	Bi	Ca	Cd	Co	Cr	Cu	Fe	K	Li	Mg	Mn	Mo	Na	Ni	Pb	Rb	Sb	Se	Sn	Sr	Te	Tl	U	V	Zn
MBG	0.2	26500	6.7	2.0	71	1.0	5.0	2500	0.2	15	30	12	38000	1311	28	6000	740	0.4	100	30	16	30	0.2	2.0	0.5	10	0.2	0.3	1.0	50	64
CCME ISQG (pp	40	N/A	12	N/A	2000	8	N/A	N/A	22	300	87	91	N/A	N/A	N/A	N/A	N/A	40	N/A	50	600	N/A	40	3.9	300	N/A	N/A	1	N/A	130	360

Legend:

BLUE: Exceeds MBG

RED: Exceeds ISQG

Table 11 f) Metal Analysis for Soil Samples, Antitank Range, phase III: Depth profiles Front and Back of Firing Position

Sample	Ag	Al	As	B	Ba	Be	Bi	Ca	Cd	Co	Cr	Cu	Fe	K	Li	Mg	Mn	Mo	Na	Ni	Pb	Rb	Sb	Se	Sn	Sr	Te	Tl	U	V	Zn	Sample description
	Concentration (ppm)																															
GAG145	0.2	13900	4	**4**	29	0.3	**14**	390	0.2	6.8	16	6	22800	510	12.2	2190	391	**0.6**	<50	14	10.3	12.8	<0,1	1	**3.6**	5	<0,1	0.3	0.5	36	59	Center FP Wellington 10m Front 0 to 5 cm
GAG146	0.1	14600	3	2	27	0.3	2	340	0.1	8	15	5	16800	500	13.3	2090	328	0.3	<50	11	7.4	15.4	<0,1	<1	**3**	4	<0,1	0.3	0.5	29	49	Center FP Wellington 10m Front 5 to 7 cm
GAG147	0.1	20600	3	2	37	0.6	1	370	0.1	**26.8**	20	5	29900	690	19.1	3190	**1580**	0.3	<50	16	11.9	21.6	<0,1	<1	**3.8**	5	<0,1	**0.4**	0.7	40	61	Center FP Wellington 10m Front 7 to 11.5 cm
GAG148	<0,1	23000	4	2	40	0.7	<1	460	0.2	**24.1**	25	6	30200	840	24.5	4270	**1090**	0.3	<50	21	10.3	23.4	<0,1	<1	**3.9**	6	<0,1	**0.4**	0.7	41	**72**	Center FP Wellington 10m Front 11.5 to 13 cm
GAG149	<0,1	24100	3	2	42	0.6	<1	440	<0,1	13.7	24	6	26300	940	24.2	4670	399	0.3	<50	23	7.5	26.1	<0,1	<1	**4**	5	<0,1	0.3	0.7	34	**75**	Center FP Wellington 10m Front 13 to 18 cm
GAG150	<0,1	19300	3	**3**	36	0.5	<1	510	0.1	14.5	20	6	22900	910	19	4000	558	0.2	120	19	7.8	22.3	<0,1	<1	**3.6**	5	<0,1	**0.4**	0.7	31	57	Center FP Wellington 10m Front 18 to 22 cm
GAG151	<0,1	14700	3	2	32	0.5	<1	460	<0,1	12	20	6	20400	880	16.2	4270	417	0.2	<50	20	7.2	16.8	<0,1	<1	**3.6**	6	<0,1	0.3	0.6	30	52	Center FP Wellington 10m Front 22 to 27 cm
GAG152	<0,1	14500	4	1	34	0.5	<1	490	<0,1	12	20	7	24400	980	16	4680	398	0.2	<50	22	8	16.2	<0,1	<1	**3.9**	6	<0,1	0.3	0.7	32	55	Center FP Wellington 10m Front 27 to 31 cm
GAG153	<0,1	15300	3	2	40	0.6	<1	560	<0,1	11.8	22	9	21300	1170	17.1	5060	397	0.2	<50	25	7.7	17.7	<0,1	<1	**3.9**	7	<0,1	0.3	0.7	34	58	Center FP Wellington 10m Front 31 to 35 cm
GAG154	<0,1	12500	3	2	33	0.5	<1	780	0.1	10.6	19	9	20400	950	14.2	4380	354	0.2	<50	21	7.7	13	<0,1	<1	**3.8**	8	<0,1	0.3	0.8	29	50	Center FP Wellington 10m Front 35 to 39 cm
GAG155	<0,1	11700	3	**3**	31	0.4	<1	720	<0,1	9.1	17	7	16700	910	12.9	4070	305	0.1	<50	19	7.1	12.3	<0,1	<1	**3.8**	10	<0,1	0.2	0.7	27	47	Center FP Wellington 10m Front 39 to 42 cm
GAG156	<0,1	12000	3	**4**	33	0.4	<1	850	**0.3**	9.9	18	8	19500	1120	13.5	4490	329	0.1	330	21	7.4	12.8	<0,1	<1	**3.7**	8	<0,1	0.3	0.7	29	49	Center FP Wellington 10m Front 42 to 47 cm
GAG157	<0,1	10600	4	**4**	29	0.4	<1	830	<0,1	9.3	17	8	19000	920	12.6	4190	314	0.2	<50	20	7.1	11.4	<0,1	1	**3.8**	8	<0,1	0.2	0.7	30	47	Center FP Wellington 10m Front 47 to 52 cm
GAG158	<0,1	9940	3	**4**	29	0.4	<1	790	<0,1	9.8	15	10	16900	820	11.5	3780	440	0.1	<50	18	6.7	9.8	<0,1	<1	**3.9**	7	<0,1	0.2	1	25	42	Center FP Wellington 10m Front 52 to 57 cm
GAG159	<0,1	12000	3	2	26	0.6	<1	580	<0,1	9.5	16	7	21700	820	14	3200	363	0.2	<50	20	7.1	8.9	<0,1	<1	**4.1**	4	<0,1	0.2	0.5	23	50	Center FP Wellington 10m Back 0 to 5 cm
GAG160	<0,1	10200	3	1	24	0.6	<1	380	<0,1	9	13	6	19600	680	11.8	2670	254	0.2	<50	18	6.6	8.3	<0,1	<1	**3.9**	4	<0,1	0.2	0.5	23	44	Center FP Wellington 10m Back 5 to 10 cm
GAG161	<0,1	11100	3	2	24	0.5	<1	550	<0,1	9.8	16	7	21300	700	14	3060	378	0.2	<50	21	7.1	8.4	<0,1	<1	**4.1**	6	<0,1	0.2	0.5	23	49	Center FP Wellington 10m Back 10 to 20 cm
GAG162	<0,1	10100	4	2	**80**	0.6	<1	640	0.1	7.7	14	10	19300	840	10.9	2200	394	0.3	<50	14	14.4	10.1	<0,1	<1	**3.7**	9	<0,1	0.2	0.7	24	53	Center FP Wellington 10m Back 20 to 27 cm
GAG163	<0,1	2950	<1	**3**	17	<0,1	<1	260	<0,1	1	5	2	6180	290	1.3	380	55	<0,1	<50	2	3.7	6.2	<0,1	<1	**3.1**	3	<0,1	0.2	0.3	10	10	Center FP Wellington 10m Back 27 to 35 cm
GAG164	0.1	22900	6	2	34	0.4	<1	420	<0,1	7.2	25	5	37500	830	16	2930	270	0.3	<50	14	12.7	27.9	<0,1	<1	**4.1**	5	<0,1	**0.4**	0.6	49	49	Center FP Wellington 10m Back 35 to 39 cm
GAG165	0.1	**34600**	4	**3**	38	0.7	<1	390	<0,1	12.7	29	7	30100	900	**28.6**	3560	261	0.4	<50	22	10.7	23.8	<0,1	<1	**4.2**	5	<0,1	0.3	0.7	40	**94**	Center FP Wellington 10m Back 39 to 42 cm
GAG166	<0,1	**28700**	4	**3**	44	0.7	<1	420	<0,1	**17.8**	29	9	25900	960	27.8	4430	318	0.4	60	30	8.3	23.5	<0,1	<1	**4**	6	<0,1	0.3	0.8	39	**94**	Center FP Wellington 10m Back 42 to 47 cm
GAG167	<0,1	23400	4	2	42	0.7	<1	420	<0,1	13.3	26	9	25600	970	24.8	4800	348	0.4	<50	28	8.6	23.8	<0,1	<1	**4**	6	<0,1	0.3	0.8	38	**80**	Center FP Wellington 10m Back 47 to 50 cm
GAG168	<0,1	21100	5	2	44	0.7	<1	420	<0,1	12.1	26	8	27200	920	23.4	4610	337	0.3	<50	25	8.6	23.2	<0,1	<1	**4.1**	6	<0,1	0.3	0.8	41	**70**	Center FP Wellington 10m Back 50 to 56 cm
GAG169	<0,1	22500	4	2	50	0.7	<1	560	<0,1	13.7	30	9	28900	1190	24.9	5900	404	0.3	<50	30	9.7	24.6	<0,1	<1	**4.6**	8	<0,1	0.3	0.8	43	**75**	Center FP Wellington 10m Back 56 to 59 cm
GAG170	<0,1	13400	4	2	32	0.6	<1	600	<0,1	10.8	21	8	23300	980	16.4	4470	371	0.3	<50	23	7.7	14.9	<0,1	<1	**4**	8	<0,1	0.3	0.8	35	55	Center FP Wellington 10m Back 59 to 63 cm

MBG	0.2	26500	6.7	2.0	71	1.0	5.0	2500	0.2	15	30	12	38000	1311	28	6000	740	0.4	100	30	16	30	0.2	2.0	0.5	10	0.2	0.3	1.0	50	64
CCME ISQG (p	40	N/A	12	N/A	2000	8	N/A	N/A	22	300	87	91	N/A	N/A	N/A	N/A	N/A	40	N/A	50	600	N/A	40	3.9	300	N/A	N/A	1	N/A	130	360

Legend:
BLUE: Exceeds MBG
RED: Exceeds ISQG

Table 11 g) Metal Analysis for Soil Samples, Grenade ranges: New-Castle hand grenade (NCHGR) and New-Castle Riffle grenade (NCRGR)

Sample	Ag	Al	As	B	Ba	Be	Bi	Ca	Cd	Co	Cr	Cu	Fe	K	Li	Mg	Mn	Mo	Na	Ni	Pb	Rb	Sb	Se	Sn	Sr	Te	Tl	U	V	Zn	CRREL ID	Sample information
Riffle grenade	Concentration (ppm)																																
S-NCRGR-T1 BACK	< 0,1	8320	4	< 1	39	0.4	< 1	1030	< 0,1	7.7	15	5	16600	580	11.5	3550	333	0.1	< 50	13	9.1	10.8	< 0,1	< 1	< 0,1	10	< 0,1	< 0,1	0.6	26	34		
S-NCRGR-T2 BACK	< 0,1	8050	6	< 1	50	0.4	< 1	1610	< 0,1	8	16	11	15600	700	11.8	3830	400	0.1	< 50	15	11	9	< 0,1	< 1	< 0,1	12	< 0,1	< 0,1	0.7	23	43		
S-NCRGR-Right 100m	<0,1	10800	3	1	55	0.5	<1	1930	<0,1	10.1	20	12	22000	960	15.2	3830	431	0.3	50	19	10.5	14.8	0.1	<1	4.8	17	<0,1	0.4	0.7	34	48	GAG 096	Front of Target Right 100m - 130m
S-NCRGR-Center 100m(Sonia)	<0,1	10800	4	1	65	0.7	<1	2270	<0,1	11.3	20	9	22200	1090	16.5	4260	512	0.2	60	22	9.9	13.6	0.1	<1	3.8	20	<0,1	0.3	0.8	30	54	GAG 097	Front of Target Center 100m - 130m
S-NCRGR-Left 100m (TAR)	<0,1	10600	4	1	55	0.6	<1	1750	<0,1	9.5	18	14	20900	1020	15.9	3840	450	0.3	<50	19	12.4	13.7	<0,1	<1	3.8	14	<0,1	0.4	0.8	29	48	GAG 098	Front of Target Left 100m - 130m
S-NCRGR-Right 200m (TAR)	<0,1	11100	3	1	36	0.3	<1	800	0.1	7.5	17	10	18800	800	13.7	2860	332	0.2	90	14	12.4	18.2	<0,1	<1	3.8	10	<0,1	0.3	0.6	32	41	GAG 099	Behind Metal Plate Targets Right 170m - 200m
S-NCRGR-Center 200m(Sonia)	<0,1	9680	3	<1	37	0.3	<1	1100	<0,1	8.3	14	4	18100	740	12.4	2980	398	0.2	<50	14	11.6	16.9	<0,1	<1	3.7	11	<0,1	0.3	0.6	31	38	GAG 100	Behind Metal Plate Targets Center 170m - 200m
S-NCRGR-Left 200m(Annie)	<0,1	11100	4	1	50	0.4	<1	1550	<0,1	8.8	17	33	19600	920	14.9	3200	455	0.3	<50	16	18.1	17.5	<0,1	<1	4	14	<0,1	0.4	0.7	35	46	GAG 101	Behind Metal Plate Targets Left 170m - 200m
S-NCRGR-Left 200m (Dup)(Andr	<0,1	10900	3	<1	50	0.4	<1	1640	<0,1	8.1	17	238	18500	890	13.8	3180	430	0.4	<50	15	23.8	16.4	0.1	<1	4	16	<0,1	0.4	0.8	30	47	GAG 102	Behind Metal Plate Targets Left 170m - 200m (Dupe)
Hand grenade																																	
S-NCHGR-10M	< 0,1	8140	4	< 1	61	0.5	< 1	860	< 0,1	6.4	20	41	18700	690	11.7	3880	315	0.1	< 50	26	16.8	7.8	0.2	< 1	< 0,1	7	< 0,1	< 0,1	0.7	20	632		
S-NCHGR-20M	< 0,1	8140	5	< 1	57	0.6	< 1	860	< 0,1	6.3	19	44	18100	670	11.9	4140	321	0.1	< 50	22	13.6	7.3	0.2	< 1	< 0,1	6	< 0,1	< 0,1	0.8	21	410		
S-NCHGR-30M	< 0,1	7710	5	< 1	55	0.5	< 1	870	< 0,1	6.1	18	32	17000	670	11.9	3820	304	0.1	< 50	23	14.7	7.8	0.2	< 1	< 0,1	6	< 0,1	< 0,1	0.6	18	471		
S-NCHGR-30M-DUP1	< 0,1	7700	4	< 1	53	0.5	< 1	920	< 0,1	6.1	19	30	17400	650	11.4	3750	298	0.1	< 50	22	14.3	7.7	0.2	< 1	< 0,1	6	< 0,1	< 0,1	0.7	19	451		
S-NCHGR-30M-DUP2	< 0,1	8080	5	< 1	54	0.5	< 1	820	< 0,1	6.2	19	32	17600	690	12	3900	310	0.1	< 50	23	15.3	7.9	0.2	< 1	< 0,1	6	< 0,1	< 0,1	0.8	22	495		
S-NCHGR-40M	< 0,1	6680	4	< 1	36	0.5	< 1	960	< 0,1	5.4	14	101	14600	590	10.6	3460	263	0.1	< 50	17	8.5	6.8	0.2	< 1	0.2	5	< 0,1	< 0,1	0.6	17	224		
S-NCHGR-50M	< 0,1	8780	5	< 1	50	0.6	< 1	850	< 0,1	6.5	18	20	16500	710	12.9	4290	367	< 0,1	< 50	21	11.2	8.8	0.1	< 1	< 0,1	6	< 0,1	< 0,1	0.7	19	190		
S-NCHGR-10m 25 inc	<0,1	7970	4	1	62	0.6	<1	2530	0.2	7.1	19	65	18500	620	13.4	3860	337	0.2	50	27	12.9	6.7	0.2	<1	3.4	12	<0,1	0.1	0.6	24	592	GAG 078	10m Line (55m wide)
S-NCHGR-20m 25 inc (SONIA)	<0,1	7680	4	1	61	0.6	<1	2490	0.2	7.6	24	49	24900	590	13.2	3650	372	0.5	70	32	15.1	6.4	0.2	<1	3.6	10	<0,1	<0,1	0.5	26	755	GAG 079	20m Line Rep 1
S-NCHGR-20m 25 inc (TAR)	<0,1	8650	5	1	65	0.6	<1	2430	0.3	7.7	23	63	20300	1220	13.2	3470	332	0.3	380	31	18.8	8.6	0.3	<1	4.2	12	<0,1	<0,1	0.7	26	657	GAG 080	20m Line Rep 2
S-NCHGR-30m 25 inc	<0,1	7080	3	2	48	0.4	<1	860	0.1	5.6	16	44	16900	610	11.3	3020	269	0.2	50	23	13.7	6.9	0.2	<1	4.1	6	<0,1	0.4	0.5	19	510	GAG 081	30m Line
S-NCHGR-40m 25 inc (SONIA)	<0,1	7200	4	2	42	0.6	<1	760	<0,1	5.9	16	22	15600	660	12.2	3020	302	0.2	<50	21	11	7.3	0.2	<1	4	6	<0,1	0.3	0.6	19	374	GAG 082	40m Line Rep 1
S-NCHGR-40m 25 inc (TAR)	<0,1	6950	4	1	44	0.5	<1	730	0.2	6.2	18	27	14800	660	11.4	2910	288	0.2	<50	24	11.5	7.2	0.2	1	3.8	5	<0,1	0.3	0.6	19	412	GAG 083	40m Line Rep 2
S-NCHGR-50m 25 inc	<0,1	7960	4	1	46	0.6	<1	750	0.1	6.8	17	25	15800	660	13	3190	315	0.2	60	24	11.1	7.7	0.2	<1	4	6	<0,1	0.3	0.6	19	330	GAG 084	50m Line
S-NCHGR-L1 30 inc	<0,1	7100	3	<1	43	0.4	<1	1080	<0,1	6.5	16	30	14100	600	11.4	3350	275	0.2	<50	24	9.5	6.1	0.2	<1	4.1	6	<0,1	0.3	0.5	16	436	GAG 085	Left 1 (0-5m)
S-NCHGR-L2 30 inc	<0,1	7680	4	1	44	0.5	<1	1320	0.1	6.1	16	21	16300	660	11.6	3280	306	0.2	<50	21	9.5	7	0.1	<1	4.3	7	<0,1	0.3	0.6	23	1190	GAG 086	Left 2 Rep 1 (5-10m)
S-NCHGR-L2 (dup) 30 inc	<0,1	7380	3	<1	37	0.5	<1	790	<0,1	7	18	18	17100	560	12	3450	298	0.1	50	20	8.5	6.1	0.2	<1	4	6	<0,1	0.3	0.5	20	256	GAG 087	Left 2 Rep 2 (5-10m)
S-NCHGR-L3 30 inc	<0,1	6460	3	<1	36	0.5	<1	660	0.1	5.4	13	13	14400	610	10.1	2760	281	0.1	<50	16	7.5	6.3	0.1	<1	4	5	<0,1	0.3	0.6	20	205	GAG 088	Left 3 (10-15m)
S-NCHGR-L4 30 inc (TAR)	<0,1	8510	4	<1	40	0.6	<1	930	<0,1	7.1	24	44	28200	640	15.4	4380	390	0.3	<50	22	7.2	7	0.2	<1	4	7	<0,1	0.3	0.7	24	214	GAG 089	Left 4 (15-20m)
S-NCHGR-R1 30 inc (TAR)	<0,1	7090	3	<1	28	0.5	<1	890	<0,1	4.8	13	16	13100	590	9.2	3040	273	0.2	<50	15	7.3	5.6	0.1	<1	3.3	5	<0,1	0.2	0.4	16	265	GAG 090	Right 1 Rep 1 (0-5m)
S-NCHGR-R1 (dup) 30 inc(TAR)	<0,1	9140	4	1	48	0.6	<1	1230	<0,1	6.9	17	28	19400	760	13.6	3560	392	0.2	110	22	15.3	8.4	0.2	<1	4	6	<0,1	0.3	0.7	25	291	GAG 091	Right 1 Rep 2 (0-5m)
S-NCHGR-R2 30 inc	<0,1	7320	4	<1	34	0.5	<1	720	<0,1	6.1	13	31	15000	630	11.4	3210	301	0.1	60	18	8.1	6.7	0.2	<1	3.7	5	<0,1	0.3	0.6	20	241	GAG 092	Right 2 (5-10m)
S-NCHGR-R3 30 inc	<0,1	7580	5	<1	37	0.6	<1	620	0.1	6.5	14	18	16900	680	12.3	3110	335	0.5	60	18	9	7.8	0.2	<1	4.1	5	<0,1	0.3	0.6	21	110	GAG 093	Range Right 3 (10-15m)
S-NCHGR-R4 30 inc	<0,1	6960	3	<1	27	0.4	<1	610	<0,1	5.2	15	20	13400	550	10.9	3020	279	0.1	<50	16	6.1	6	0.1	<1	4	5	<0,1	0.3	0.5	16	69	GAG 094	Right 4 (15-20m)
S-NCHGR-Rear 30 inc	<0,1	8750	4	<1	35	0.5	<1	660	0.1	6.3	15	17	14800	660	12.3	3120	324	0.2	50	17	27	8.8	0.5	<1	4	6	<0,1	0.3	0.6	21	86	GAG 095	Rear (50-60m accross back of range, 55m wide)

	Ag	Al	As	B	Ba	Be	Bi	Ca	Cd	Co	Cr	Cu	Fe	K	Li	Mg	Mn	Mo	Na	Ni	Pb	Rb	Sb	Se	Sn	Sr	Te	Tl	U	V	Zn
MBG	0.2	26500	6.7	2.0	71	1.0	5.0	2500	0.20	15	30	12	38000	1311	28	6000	740	0.40	100	30	16	30	0.20	2.00	0.50	10	0.2	0.3	1.0	50	64
CCME ISQG (ppm)	40	N/A	12	N/A	2000	8	N/A	N/A	22	300	87	91	N/A	N/A	N/A	N/A	N/A	40	N/A	50	600	N/A	40	3.9	300	N/A	N/A	1	N/A	130	360

Legend:
BLUE: Exceeds MBG
RED: Exceeds ISQG

2002 results
2003 results

Table 11h) Metal Analysis for Soil Samples, Hersey Range, BIP of a 500

Sample	Ag	Al	As	B	Ba	Be	Bi	Ca	Cd	Co	Cr	Cu	Fe	K	Li	Mg	Mn	Mo	Na	Ni	Pb	Rb	Sb	Se	Sn	Sr	Te	Tl	U	V	Zn	sample description
	Concentration (ppm)																															
GAG 066	0.1	7790	2	2	**99**	0.5	1	2190	**0.5**	10	13	**15**	15300	920	9.2	2360	**1170**	0.3	70	15	13	14.3	<0,1	<1	**2.4**	**24**	<0,1	0.1	0.4	24	56	500-lb Bomb Pre-Blast 5m to 20m from bomb marshy side 10 incs
GAG 067	<0,1	7750	2	1	47	0.3	<1	550	0.1	5.3	10	7	12500	540	7	1660	181	0.2	<50	10	9.2	15.9	<0,1	<1	**2.9**	9	<0,1	0.1	0.4	26	27	500-lb Bomb Pre-Blast SubSurface 5m to 20m from bomb marshy side 10 incs
GAG 068	<0,1	7520	2	2	**94**	0.4	<1	2200	**0.4**	7.4	13	**22**	14900	1020	8.8	2440	**804**	0.2	60	15	**208**	13.2	<0,1	<1	**3.2**	**22**	<0,1	0.1	0.5	24	54	500-lb Bomb Pre-Blast Surface 5m to 10m from bomb 10 incs
GAG 069	0.1	7620	2	2	63	0.3	<1	1120	0.1	6.4	12	9	15300	710	7.2	1850	328	0.2	80	12	11.1	14.8	0.2	<1	**3.4**	**14**	<0,1	0.1	0.4	28	32	500-lb Bomb Pre-Blast SubSurface 5m to 10m from bomb 10 incs
GAG 070	<0,1	11000	3	1	**123**	1	<1	**2520**	**0.3**	14.4	23	11	26800	1240	16.7	4360	**1020**	0.2	70	29	7.9	14.4	<0,1	1	**4.1**	**31**	<0,1	0.1	0.7	35	54	500-lb Bomb Post-Blast Crater Wall, Rep 1, 63 incs approx 1mX1m grid
GAG 071	<0,1	10900	3	1	**116**	0.9	<1	**2660**	**0.3**	14	23	12	26600	**1350**	16.4	4440	**978**	0.2	**180**	29	8.7	15.2	<0,1	<1	**6**	**32**	<0,1	0.1	0.7	37	57	500-lb Bomb Post-Blast Crater Wall, Rep 2, 63 incs approx 1mX1m grid
GAG 072	<0,1	10800	4	1	**124**	0.9	<1	**2560**	**0.3**	14.1	23	12	26100	1250	16.5	4300	**1140**	0.3	80	28	9	14.4	<0,1	<1	**3.8**	**31**	<0,1	0.1	0.8	34	54	500-lb Bomb Post-Blast Crater Wall, Rep 3, 63 incs approx 1mX1m grid
GAG 073	<0,1	10400	3	<1	**114**	0.7	<1	1980	0.2	12.4	21	10	24400	1090	14.7	3850	**914**	0.2	**120**	25	8.9	13.8	0.1	<1	**3.9**	**23**	<0,1	0.1	0.7	35	46	500-lb Bomb Post-Blast Rim to 10m from edge Rep 1
GAG 074	<0,1	10600	4	<1	**96**	0.8	<1	1930	0.2	13	20	9	24300	1070	15.5	3930	707	0.2	**120**	24	7.9	13.3	0.1	<1	**3.9**	**22**	<0,1	0.1	0.7	34	46	500-lb Bomb Post-Blast Rim to 10m from edge Rep 2
GAG 075	<0,1	10500	3	<1	**89**	0.7	<1	1870	**0.3**	11.5	20	10	24700	990	14.5	3680	**769**	0.2	100	22	8.7	13.3	<0,1	<1	**4.8**	**21**	<0,1	0.1	0.7	37	46	500-lb Bomb Post-Blast Rim to 10m from edge Rep 3
GAG 076	<0,1	8990	3	1	**88**	0.6	<1	1870	0.2	10.2	16	11	19400	890	11.5	3080	599	0.2	50	19	9.3	14.1	0.1	<1	**2.7**	**20**	<0,1	0.1	0.6	29	49	500-lb Bomb Post-Blast 10m to 20m from edge surface only, 25 incs
GAG 077	<0,1	8770	3	2	**93**	0.6	<1	1800	**0.4**	10.6	16	**13**	19500	850	12.2	2900	649	0.3	<50	19	10.8	13.8	0.1	<1	**3**	**20**	<0,1	0.1	0.6	30	53	500-lb Bomb Post-Blast 10m to 20m from edge surface only, 25 incs
MBG	0.2	26500	6.7	2.0	71	1.0	5.0	2500	0.2	15	30	12	38000	1311	28	6000	740	0.4	100	30	16	30	0.2	2.0	0.5	10	0.2	0.3	1.0	50	64	
CCME ISQG (	40	N/A	12	N/A	2000	8	N/A	N/A	22	300	87	91	N/A	N/A	N/A	N/A	N/A	40	N/A	50	600	N/A	40	3.9	300	N/A	N/A	1	N/A	130	360	

Legend:
BLUE: Exceeds MBG
RED: Exceeds ISQG

pre-detonati
post-detona

Table 11 i) Metal Analysis for Soils Samples Propellant Burning Pads (S-BP)

Sample	Ag	Al	As	B	Ba	Be	Bi	Ca	Cd	Co	Cr	Cu	Fe	K	Li	Mg	Mn	Mo	Na	Ni	Pb	Rb	Sb	Se	Sn	Sr	Te	Tl	U	V	Zn
	Concentration (ppm)																														
S-BP-1A	< 0,1	8060	2	< 1	37	0.7	2	1010	< 0,1	9.6	15	**24**	22100	750	9.4	3500	281	0.2	< 50	20	**384**	7.1	0.2	< 1	0.4	**33**	< 0,1	< 0,1	0.7	20	46
S-BP-1A dup	< 0,1	7870	2	< 1	34	0.6	< 1	980	< 0,1	9.5	14	**16**	21400	760	9.4	3520	270	0.2	< 50	19	**252**	7.1	**0.4**	< 1	**0.6**	8	< 0,1	< 0,1	0.7	20	45
S-BP-1B	< 0,1	9480	2	2	36	0.7	< 1	1520	< 0,1	11.3	17	**19**	23500	910	10.9	3980	333	0.2	< 50	22	**872**	9.2	0.2	< 1	0.1	**15**	< 0,1	0.1	0.8	23	52
S-BP2-A	0.1	6590	2	< 1	**92**	0.3	< 1	1320	< 0,1	5.2	10	9	12900	630	7.3	2340	349	< 0,1	< 50	10	**8410**	5.1	**0.3**	< 1	0.4	**3640**	< 0,1	**0.4**	0.4	14	29
S-BP2-A-Dup	< 0,1	7000	2	< 1	**102**	0.4	< 1	1430	< 0,1	5.6	10	10	13500	640	7.9	2560	358	< 0,1	< 50	11	**7060**	5.4	< 0,1	< 1	0.4	**3950**	< 0,1	**0.4**	0.4	14	30
S-BP2-B	< 0,1	8540	6	< 1	34	0.5	< 1	1660	< 0,1	7.7	14	9	18000	720	10.8	3410	660	0.2	< 50	14	**560**	8.5	0.1	< 1	< 0,1	**222**	< 0,1	< 0,1	0.6	22	**105**
S-BP-1A	<0,1	11200	3	<1	35	1	<1	1720	0.2	10.8	18	**21**	25600	1150	12.9	3320	369	0.3	<50	22	**318**	10.3	**0.6**	<1	0.5	**125**	<0,1	<0,1	0.8	29	**96**
S-BP-1B	0.1	8300	2	<1	**165**	0.7	<1	1830	0.2	9.5	14	**27**	21500	1270	9.7	3200	283	0.2	100	19	**58700**	7.4	**0.9**	<1	**2.1**	**5980**	<0,1	0.2	0.5	20	**74**
S-BP-1B Lab Dup.	0.2	8380	2	<1	**135**	0.7	<1	1780	0.2	10.8	17	**28**	21100	1240	10.9	3300	294	0.2	100	22	**58500**	7.9	**0.8**	<1	**1.4**	**5180**	<0,1	**0.4**	0.6	24	55
S-BP-2A	<0,1	8440	2	<1	42	0.7	<1	1670	0.2	6.9	12	8	15600	940	9.6	2890	418	0.4	50	12	**1960**	7.8	0.2	<1	<0,1	**654**	<0,1	<0,1	0.5	20	38
S-BP-2B	<0,1	7340	6	<1	63	0.4	<1	1660	0.1	7.3	14	9	16600	1070	9.3	2690	488	**0.6**	80	14	**1380**	7.7	**0.4**	<1	<0,1	**431**	<0,1	<0,1	0.5	19	41
S-BP-3A	<0,1	12200	**14**	<1	**143**	**1.1**	<1	800	0.2	**15.8**	18	**15**	28800	1300	19.8	4230	730	**0.5**	<50	22	**54.7**	10.2	0.2	<1	<0,1	**91**	<0,1	0.1	0.9	24	51
S-BP-4A	<0,1	15200	2	<1	50	**1.2**	<1	**4340**	0.1	12	20	**14**	19600	**1760**	18.9	**7760**	678	0.1	<50	22	**51.1**	7.1	0.1	<1	<0,1	**78**	<0,1	<0,1	0.6	31	63
S-BP-4B	<0,1	12200	1	<1	48	0.9	<1	**4550**	<0,1	8.6	14	9	13900	1200	13.3	5670	463	<0,1	<50	16	**178**	6	<0,1	<1	<0,1	**64**	<0,1	<0,1	0.5	22	39
MBG	0.2	26500	6.7	2.0	71	1.0	5.0	2500	0.2	15	30	12	38000	1311	28	6000	740	0.4	100	30	16	30	0.2	2.0	0.5	10	0.2	0.3	1.0	50	64
CCME ISQG (ppm)	40	N/A	12	N/A	2000	8	N/A	N/A	22	300	87	91	N/A	N/A	N/A	N/A	N/A	40	N/A	50	600	N/A	40	3.9	300	N/A	N/A	1	N/A	130	360

2002 results
2003 results

Legend:
BLUE: Exceeds MBG
RED: Exceeds ISQG

Table 11 j) Metal Analysis for Soils Samples- Vimy Small Arms Ranges

Sample	Ag	Al	As	B	Ba	Be	Bi	Ca	Cd	Co	Cr	Cu	Fe	K	Li	Mg	Mn	Mo	Na	Ni	Pb	Rb	Sb	Se	Sn	Sr	Te	Tl	U	V	Zn
	Concentration (ppm)																														
S-VIMY 1-4	< 0,1	7300	6	< 1	42	0.4	< 1	750	< 0,1	5.6	13	**33**	15400	700	9.2	3140	340	0.1	100	15	**381**	6.4	**4**	< 1	**1.1**	7	< 0,1	< 0,1	0.6	18	29
S-VIMY 5-8	< 0,1	7840	4	< 1	43	0.6	< 1	1200	< 0,1	5.8	14	**89**	16700	780	10.6	3520	355	0.2	100	15	**1040**	7.3	**9.9**	< 1	**2.7**	**18**	< 0,1	< 0,1	0.7	18	38
S-VIMY 9-12	**0.9**	8920	**8**	< 1	36	0.5	3	**3250**	< 0,1	6.2	15	**379**	18700	890	11.4	3900	471	0.2	80	16	**13500**	8	**140**	< 1	**32.1**	**30**	**0.8**	**0.6**	0.7	21	**77**
S-VIMY 1-DEPTH	< 0,1	6990	6	< 1	25	0.4	< 1	2060	< 0,1	4.4	12	**28**	13400	1130	13.3	3580	288	0.1	60	10	**673**	14.2	**12.4**	< 1	**2.3**	**15**	< 0,1	0.1	0.9	22	32
S-V-FP(100m)	<0,1	8240	4	<1	42	0.5	<1	1920	<0,1	6.7	13	**66**	16300	720	13.5	3350	476	0.2	**180**	13	**273**	7.7	**2.7**	<1	0.1	8	<0,1	<0,1	0.7	20	46
S-V-FP(100m) dup.	<0,1	13300	6	<1	46	0.6	1	**2530**	<0,1	10.3	19	**39**	21600	980	18	4670	**751**	0.4	**400**	20	**168**	12.8	**1.3**	<1	0.1	8	<0,1	<0,1	0.9	27	58
S-V-FP(200m)	<0,1	13200	6	<1	49	0.5	<1	1820	<0,1	9.9	18	**21**	20400	1010	17.5	3760	**861**	0.4	90	17	**98.6**	14.3	**0.7**	<1	0.1	8	<0,1	0.1	**1.1**	26	48
S-V-FP(300m)	0.1	11000	4	<1	38	0.5	1	1710	<0,1	8.4	16	**59**	18400	1020	15.4	3750	485	0.2	< 50	16	**539**	11.1	**3.7**	<1	0.5	10	<0,1	<0,1	0.8	25	45
S-V-T1-T4	**0.8**	8120	**9**	<1	34	0.5	3	2090	0.1	5.9	14	**1510**	15400	920	13	3730	354	0.4	60	13	**89200**	9.3	**157**	<1	**33.2**	**63**	**0.5**	**0.7**	0.8	30	**199**
S-V-T5-T8	**0.6**	10400	**11**	<1	40	0.5	2	**5060**	0.1	8.1	20	**978**	20900	1090	15.5	5190	674	**0.5**	60	18	**43000**	9.5	**83.7**	<1	**20**	**62**	**0.3**	**0.5**	**1.9**	24	**167**
S-V-T5-T8 FIELD DUP	**0.7**	7930	**8**	<1	31	0.5	3	2030	0.1	5.9	13	**947**	15300	890	12.9	3340	346	0.4	70	13	**34900**	8.4	**121**	<1	**31.6**	**60**	**0.3**	**0.6**	0.6	20	**144**
S-V-T5-T8 FIELD DUP LAB DUP	**0.6**	7570	**8**	<1	38	0.5	2	1670	<0,1	6.2	13	**1100**	14000	820	12.7	3200	354	0.3	< 50	14	**24100**	8.9	**103**	<1	**23.6**	**54**	**0.4**	**0.5**	0.6	18	**173**
S-V-T9-T12	**0.4**	8210	5	<1	34	0.5	3	1910	<0,1	6.5	14	**577**	15900	810	12.9	3610	337	0.2	< 50	14	**18600**	8	**49.7**	<1	**26.6**	**13**	**0.3**	0.3	0.7	18	**94**
S-V-T1 DEPTH	**1.3**	7790	**11**	<1	30	0.5	**8**	2210	<0,1	5	11	**1910**	14200	1150	13.5	3340	339	**0.6**	80	11	**39400**	11.6	**324**	<1	**45.4**	**125**	**0.8**	**1.2**	0.9	18	**249**
S-V-T5 DEPTH	**0.9**	10100	**11**	<1	36	0.5	4	**3800**	0.1	8	17	**940**	20700	1080	14.8	4860	518	0.4	70	19	**34300**	9.9	**169**	<1	**35.2**	**133**	**0.5**	**0.7**	0.8	23	**152**
MBG	0.2	26500	6.7	2.0	71	1.0	5.0	2500	0.2	15	30	12	38000	1311	28	6000	740	0.4	100	30	16	30	0.2	2.0	0.5	10	0.2	0.3	1.0	50	64
CCME ISQG (ppm)	40	N/A	12	N/A	2000	8	N/A	N/A	22	300	87	91	N/A	N/A	N/A	N/A	N/A	40	N/A	50	600	N/A	40	3.9	300	N/A	N/A	1	N/A	130	360
CCME RSQG (ppm)																					140										

Legend:

BLUE: Exceeds MBG

RED: Exceeds ISQG

2002 results	2003 results

Table 11 k) TCLP results for soil samples in Vimy Small Arms Range

Sample	Ag	Al	As	B	Ba	Be	Bi	Ca	Cd	Co	Cr	Cu	Fe	K	Li	Mg	Mn	Mo	Ni	Pb	Rb	Sb	Se	Sn	Sr	Te	Tl	U	V	Zn
	Concentration (mg/L)																													
S-V-FP(100m)	<0.001	0.24	<0.01	0.02	0.4	<0.01	<0.01	11.9	<0.01	0	<0.01	0.3	<0.2	5.8	<0.001	1.6	0.63	<1	<10	**11.7**	0.05	0.18	<0.01	<0.01	0.09	<0.01	<0.01	<0.01	<0.1	0.22
S-V-FP(100m) DUP	<0.001	0.27	<0.01	0.01	0.23	<0.01	<0.01	18.8	<0.01	<0.001	<0.01	0.03	<0.2	6.2	<0.001	4.1	0.34	<1	<10	0.32	0.05	0.13	<0.01	<0.01	0.06	<0.01	<0.01	<0.01	<0.1	0.06
S-V-FP(200m)	<0.001	0.42	<0.01	0.01	0.25	<0.01	<0.01	16.3	<0.01	<0.001	<0.01	0.02	<0.2	7.8	<0.001	4	0.22	<1	<10	0.33	0.08	0.02	<0.01	<0.01	0.08	<0.01	<0.01	<0.01	<0.1	0.04
S-V-FP(300m) dup	<0.001	0.35	<0.01	0.01	0.4	<0.01	<0.01	37.5	<0.01	0	<0.01	0.04	<0.2	5.3	<0.001	1.9	0.73	<1	<10	**9.92**	0.06	0.06	<0.01	<0.01	0.14	<0.01	<0.01	<0.01	<0.1	0.04
S-V-T1 DEPTH	<0.001	0.34	<0.01	<0.01	0.58	<0.01	<0.01	13.7	0.01	0.01	0.02	5.32	46.3	4.2	0.02	1.9	0.16	<1	50	**1060**	0.07	0.67	<0.01	<0.01	1.29	<0.01	0.03	0.01	<0.1	1.59
S-V-T5 DEPTH	<0.001	0.23	<0.01	<0.01	0.67	<0.01	<0.01	16.9	0.02	0.01	<0.01	11.5	1	4.7	<0.001	3.2	0.15	<1	10	**1440**	0.06	2.99	<0.01	<0.01	1.3	<0.01	0.04	0.01	<0.1	2.4
S-V-T9-T12	<0.001	0.33	<0.01	0.01	0.72	<0.01	<0.01	22.2	<0.01	0.01	<0.01	5.09	0.43	3.3	<0.001	1.8	0.11	<1	<10	**526**	0.05	2.3	<0.01	<0.01	0.31	<0.01	0.02	0.01	<0.1	0.55
S-V-T5-T8 DUP	<0.001	0.4	<0.01	<0.01	0.74	<0.01	<0.01	13.4	0.01	0.02	0.02	5.22	48.8	4	0.02	2.5	0.18	<1	50	**897**	0.07	0.62	<0.01	<0.01	1.05	<0.01	0.02	0.01	<0.1	1.13
S-V-T2-T4	<0.001	0.3	<0.01	<0.01	0.71	<0.01	<0.01	15.6	0.02	0.01	<0.01	8.5	0.76	4.8	0.02	3	0.12	<1	<10	**1110**	0.07	2.39	<0.01	<0.01	1.11	<0.01	0.03	0.01	<0.1	1.2
S-V-T5-T8	<0.001	0.26	<0.01	<0.01	0.58	<0.01	<0.01	19	<0.01	0.01	<0.01	0.87	0.41	3.8	<0.001	2.5	0.1	<1	<10	**1320**	0.05	2.41	<0.01	<0.01	0.8	<0.01	0.03	0.01	<0.1	1.04
Guideline (ppm)	5	N/A	2.5	500	100	N/A	N/A	N/A	0.50	N/A	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	5	N/A	N/A	1	N/A	N/A	N/A	N/A	10	N/A	N/A

Legend:
RED: Exceeds *** Transport Canada, dangerous goods guidelines

Table 11 l) TCLP results for soil samples from Burn Pads

Sample	Ag	Al	As	B	Ba	Be	Bi	Ca	Cd	Co	Cr	Cu	Fe	K	Li	Mg	Mn	Mo	Ni	Pb	Rb	Sb	Se	Sn	Sr	Te	Tl	U	V	Zn
	Concentration (mg/L)																													
S-BP-1A	<0.001	0.76	<0.01	0.01	0.29	<0.01	<0.01	16.5	0.04	0.01	<0.01	0.02	<0.2	7	<0.00	2.7	0.55	<0.01	<0.01	**9**	0.01	0.02	<0.1	<0.01	3.25	<0.01	<0.01	<0.0	<0.1	0.18
S-BP-1B	<0.001	0.69	<0.01	0.01	0.95	<0.01	<0.01	19.1	0.03	0	<0.01	0.05	<0.2	18.8	<0.00	2.9	0.86	<0.01	<0.01	**428**	0.01	0.01	<0.1	<0.01	72	<0.01	12	<0.0	<0.1	0.05
S-BP-2A	<0.001	0.06	<0.01	0.01	0.7	<0.01	<0.01	12.4	<0.01	<0.001	<0.01	<0.010	<0.2	15.4	<0.00	1.7	0.22	<0.01	<0.01	**104**	0	0	<0.1	<0.01	2.32	<0.01	<0.01	<0.0	<0.1	0.01
S-BP-2B	<0.001	0.57	<0.01	0.01	0.28	<0.01	<0.01	14.7	0.02	0.01	<0.01	0.01	<0.2	12.8	<0.00	1.6	1.89	<0.01	<0.01	**22.3**	0.01	0	<0.1	<0.01	6.36	<0.01	<0.01	<0.0	<0.1	0.08
S-BP-3A	<0.001	1.18	<0.01	0.01	0.43	<0.01	<0.01	6	<0.01	0.01	<0.01	0.02	<0.2	6.4	<0.00	1.1	0.39	<0.01	<0.01	1.27	0.01	0.01	<0.1	<0.01	14.7	<0.01	<0.01	<0.0	<0.1	0.03
S-BP-4A	<0.001	0.17	<0.01	<0.01	0.34	<0.01	<0.01	24.9	0.02	0	<0.01	0.02	<0.2	11.7	<0.00	4.4	1.05	<0.01	<0.01	2.03	0	0.01	<0.1	<0.01	1.46	<0.01	<0.01	<0.0	<0.1	0.07
S-BP-4B	<0.001	0.16	<0.01	0.01	0.52	<0.01	<0.01	31.4	<0.01	0	<0.01	0.01	<0.2	4.2	<0.00	4.2	0.46	<0.01	<0.01	**7.08**	0	0	<0.1	<0.01	0.69	<0.01	<0.01	<0.0	<0.1	0.02
Guideline (ppm)	5	N/A	3	500	100	N/A	N/A	N/A	0.50	N/A	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	5	N/A	N/A	1	N/A	N/A	N/A	N/A	2	N/A	N/A

Legend :RED: Exceeds *** Transport Canada, dangerous goods guidelines

Table 12. TCLP Threshold: EPA for soils and Environment and Fauna Québec regulatory levels

Metal	Regulatory level-EPA *	Regulatory level, EFQ**	Regulatory level, TC ***
	mg/L	mg/L	mg/L
Ag	5	nd	nd
As	5	5	2.5
B	nd	500	500
Ba	100	100	100
Cd	1	0.5	0.5
Cr	5	5	5
2,4 DNT	0.13	nd	0.13
Pb	5	5	5
Hg	0.2	0.1	0.1
Se	1	1	1
U	nd	2	10

nd: not determined
* result for TCLP test EPA 1311

Environmental protection Agency, Chapter One, Part 261 Identification and Listing of Hazardous Was
**Environment and Fauna Quebec regulatory levels for leachate testing of dangerous goods
*** Transport Canada, TCLP levels for dangerous goods

s for dangerous goods.

ste Subpart C- Characteristic of hazardous Waste, section 261.24 Toxicity Characteristic

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Troop readiness requires live-fire training with various types of ammunitions. By better understanding the potential environmental impacts of each type of activity, the Department of National Defence will be able to mitigate potential adverse effects. This report presents data acquired at the CFB Gagetown training area, following previous studies done in 2002 and 2001. The objective of the 2003 sampling effort was to further develop our understanding of the spatial distribution of explosives and heavy metals on five live-fire ranges, to assess their vertical migration and to verify the presence of TNT in background samples observed in 2002. DRDC-Valcartier performed the surface soils study in collaboration with Cold Regions Research and Engineering Laboratory (CRREL) scientists. In 2003 soil samples were collected in five specific area: The antitank range, the hand and riffle grenade ranges, one small arm range, the propellant burning pads and in the vicinity of the live firing area (background samples). In the antitank range, a new sampling pattern involving the collection of multiple increments (more than 50) in a large sampling area was evaluated to better assess the overall extent of soil contamination. Vertical profilings were also conducted to study the migration of munition related residues both in the impact area and in the firing position. Both energetic materials and metals were analyzed in all soil samples. For the samples collected in the small arms range and in the burning pads area, both total metals and leachate testing (TCLP) were conducted to obtain total concentrations and the bio-available concentrations of metals. Finally, pre- and post-blast area of two blow in place events where sampled. Results obtained for heavy metals confirmed the ones obtained in 2002 and showed a slow increase in concentration with time. In the target area of the antitank range, the main analytes of concern are: Cu, Ni, and Zn. In ponds located in the target area many parameters exceeded the industrial thresholds: Cu, As, Cr, Ni, Pb and Zn. In both grenade ranges, Cu, Ni and Zn are increasing in concentrations with time without reaching yet industrial thresholds. High levels of Pb and Sr were detected at the burn pads locations and in the small arms range, with in addition, levels higher than the industrial threshold for Cu, Zn and Sb in the small arm range. In both the small am range and burn pads samples, it was demonstrated that Pb is leachable when found in high concentrations. Measurable impacts of the blow in place events where seen with the elevation of the concentrations of various metal analytes. Results obtained for energetic materials demonstrated that the large area sampling strategy was successful and a better delineation of energetic residues was performed. It was demonstrated that TNT detected in 2002 in the background samples was due to sample cross-contamination. Almost no energetic residues were detected in both hand and riffle grenades, even if they have been in used for almost two years. In the antitank range, HMX is the primary analyte of concern in the target area while NG is detected at high levels in the firing line. Profiling has shown that NG migrates to a depth of 60 cm in the soil profile. HMX, TNT and NG were detected in high concentration in the ponds located in the target area.

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